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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 110. 5734

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See Advertisement page 92.

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CARDIFF WAREHOUSE—132, BUTE ST.
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See Advertisement page 28. 5701

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See Advertisement page 26, Oct. 26. 2402

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See Full Page Advt. page 63, Oct. 19.

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TWO MOTORS, 500 volts, 50 periods, 300 HP., three bearings, with transformer starters.
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TENDERS.

CONTRACTS, &c.

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND)

CONTRACTS, 1918.

The Directors of the Great Southern and Western Railway Company are prepared to receive

Tenders for the Supply of

the undermentioned STORES for Twelve Months to 31st December, 1918, or part of that period:—

	No. of Form.		No. of Form.
Acid, Sulphuric	30	Incandescent Fittings for Gas	35c
Baskets	10	India Rubber Goods	9A
Bolts, Nuts and Rivets	16	Implements, Sundry	21
Brooms and Brushes	13	Iron Tubes and Fittings	29
Brass Fittings for Carriages	18	Iron and Steel Wire	30A
Do. do. for Lamps	18A	Leather	12
Do. do. for Water	26A	Linen	8
Do. do. for Gas	26B	Linoleum	7B
Bunting	7B	Locks and Keys	19
Canvas and Sacks	6	Mats, Fibre	10
Carriage Laces	7A	Morocco	7B
Castings, Mall. Iron	11	Nails	31
Cement	34	Oak Keys	35A
Cloth Carr. and Uniforms	7C	Oak Trenails	35B
Clothing, Oil	9B	Plumbago	41
Do. I.R. proofed	9B	Railway Fastenings (Iron)	16
Coach Screws and Washers	15	Railway Fastenings (Steel)	16A
Colours	3	Rain Water Pipes and Gutters	25
Corks	39	Ropes, Twine, and Flax	4
Cotton Waste	5A	Sewer Pipes, Plaster, etc.	39
Crucibles	41	Shovels, Spades, etc.	21A
Curled Hair	7B	Soft Goods	6
Drysalteries	3	Sponge Cloths	5
Emery and Glass Cloth, etc.	28	Signal Wire Pulleys	11
Files and Tool Steel	20	Screws and Split Pins	14
Fire Bricks and Clay	33	Tin Plates	32
Foundry Requisites	42	Varnishes	1
Galv. Sheets, Buckets, etc.	23	Waste	5A
Grates, Stoves and Fenders	24	Waterproof Clothing	9B
Grindstones	28	Wicks	5
Glass, Sheet and Plate	27A	Wire, Fence and Signal	30A
Glass and China Sundries	27B	Wirework	30B
Hardware (Sundry)	17		

Forms of Tender can be obtained on *PAYMENT* of 6d. each from the COMPANY'S STOREKEEPER, AT THE GENERAL STORES, INCHICORE, Dublin, to whom enquiries for information should be made direct. Patterns may be inspected at the same place on and after the 29th instant between the hours of Ten a.m. and Four p.m. (except on Saturdays).

The Tenders to be sent in endorsed "Tender for Stores," and addressed to the undersigned, so as to be with him before Ten o'clock, a.m., on Wednesday the 14th November, 1917.

The Directors will not consider any Tender except those furnished on the Company's Forms, and do not bind themselves to accept the lowest or any Tender.

By Order,
ROBERT CRAWFORD,
Secretary.

Kingsbridge Terminus, Dublin,
October, 1917. J 174

MIDLAND GREAT WESTERN RAILWAY OF IRELAND.

CONTRACTS FOR 1918.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES. The Contracts to commence from the 1st of January next, and terminate on the 31st of December, 1918.

	No. of Form.		No. of Form.
Asbestos and Packing	1	Oils and Tallow	36
Barrows and Trucks	2	Paints, Colours and Wallpaper	37
Baskets and Mats	3	Ropes and Canvas	28
Brushes, Brooms, &c.	4	Rail Fastenings, Iron	29
Brass Fittings for Gas and Water	5	Rail Fastenings, Steel	30
Bolts, Nuts and Rivets	6	Screws, Split Pins, Nails, &c.	31
Bricks, Slates, Earthenware Pipe, &c.	7	Sheet Tin, Lead, Gun Barrel, &c.	33
Chain	8	Steel Tyres, Axles and Plates	32
Cement	9	Steel and Copper Tubes, Copper Plates and Ingots	34
Candles and Soap	10	Steel Castings	35
Carriage Fittings	11	Staffordshire Iron, Wire, &c.	38
Carriage Drimmings	12		
Creosote Oil	13		
Drysalteries	14		
Fog Signals	15		
Farm Produce Boxes	15A		
Glass	16		
Grease	17		
Gas Mantles, &c.	18		
Iron & Steel Forgings	19		
Iron Castings	20		
India Rubber Goods	21		
Lime	22		
Leather and Belting	23		
Lamps and Tinware	24		
Locks, Hainwater Goods & Hardware	25		
Springs, Steel, and Files	27		
Soft Goods	39		
Timber, &c.	30		
Tools	40		
Tool & Barrow Shafts	41		
Varnishes	42		
Wagon Covers and Tarpaulins	43		
Waste and Wicking	44		
Yorkshire Iron	45		

Forms of Tender can be obtained, on payment of 6d. each, from the STOREKEEPER, GENERAL STORES DEPARTMENT, BROADSTONE STATION, DUBLIN. *Please do not send Stamps.*

Patterns and Samples can be inspected at the same place on and after 1st prox., between the hours of Ten a.m. and Four p.m. (Saturdays, Ten a.m. to Twelve noon).

Contractors cannot be allowed to Tender to supply goods to their own patterns, nor can the Company's patterns be sent away for inspection.

The Directors will not consider any Tender unless furnished on the Company's forms; nor any Tender in which any alteration of the form has been made.

The Tenders to be sent in by post, sealed and endorsed on the envelope, "Tender for Stores, Form No. ——," and addressed to "The Chairman, Broadstone Station, Dublin," so as to reach him on or before Ten a.m. on the 13th November.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order,
PERCY A. HAY,
Broadstone Station, Dublin, Secretary.
October, 1917. J 299

APPOINTMENTS OPEN.

WALTHAMSTOW HIGHER EDUCATION COMMITTEE.

TECHNICAL INSTITUTE, WALTHAMSTOW.

Head Master, JAMES G. S. EDWARDS, A.M.I.M.E.
The Committee require the

Services of a Teacher of

Engineering Subjects for the Day Department of the above Institute.

Candidates must be ineligible for military service, and must be qualified to teach some of the following subjects:—

Practical Mathematics, Applied Mechanics, Heat Engines, Practical Geometry, Machine Drawing, Metal Work, Laboratory Work, Electricity.

Commencing salary £180 per annum, rising by £10 per annum to £250, subject to satisfactory service.

Extra remuneration will be given for Evening Work.

Application Forms, which must be returned not later than November 20th, may be obtained from

R. DEMPSEY,
1, Selborne Road, Clerk to the Governors.
Walthamstow, E. 17. J 273

COVENTRY EDUCATION COMMITTEE.

Applications are Invited for

the POST of PRINCIPAL of the Municipal Technical School.

Commencing salary £600 per annum.

Particulars of the Appointment and Forms of Application, which must be returned on or before 1st December, 1917, may be obtained from

FREDK. HORNBY,
Education Department, Secretary,
Council House, Coventry. J 331

HALIFAX EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL COLLEGE.
Principal, J. CROWTHER, B.Sc.

Applications are Invited for

the post of ASSISTANT in the Mechanical and Electrical Engineering Department. Salary £175 per annum. Candidates must be ineligible for military service. Teaching experience including laboratory work, and practical experience in an engineering works essential.

Particulars and forms of application, to be returned as early as possible, may be obtained from the PRINCIPAL, or from the undersigned.

W. H. OSTLER,
Secretary. J 135

Wanted, at Once, Teachers

of Mathematics, Machine Drawing, Applied Mechanics, &c., for Junior Technical School.—Application forms may be obtained from J. EAGLES, Principal, Technical College, Doncaster. J 182

Works Accountant Wanted,

to take charge of general office of Controlled Engineering Firm employing 600 hands. Essential qualifications—

1. Knowledge, with Practice, in Up-to-date Cost, Time and Book-keeping Systems.
2. Energy and Initiative.

State experience, naming employers, age, military liability and salary required. Progressive position for suitable man. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 181.

Records Clerk.—Wanted, a

live, energetic and keen MAN for manufacturing firm in the Midlands. Must be exempt, good at figures. Permanent and after war job, good prospects. No one on Government work will be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning A 3915 and ENGINEERING. J 214

Checker Wanted, for Drawing

Office engaged on Aircraft manufacture. A thoroughly reliable man, with good practical and technical experience for checking Jig, Tool and General Engineering Drawings. Good salary and prospects to a really first-class man. No one residing more than 10 miles away or already employed on Government work will be engaged.—Address, J 279, Offices of ENGINEERING.

Sales Manager Wanted, for

large Engineering business. Home and export trade. No one already on Government work will be engaged.—Address, stating age, experience and qualifications, J 261, Offices of ENGINEERING.

A Firm of Reinforced Concrete

Engineers and Specialists with their own head bar (well known in Lancs.), are about to APPOINT a GENERAL MANAGER.

Applicants must have had a thorough experience in this line of business and hold good clientage.

Particulars to be sent to the CHAIRMAN, Messrs. SKELTON & Co, Solicitors, 90, Deansgate, Manchester. J 288

Works Manager Wanted by

a controlled London firm of instrument makers with about 1000 employees. Good permanent opening for first-class trained engineer. Must have had previous similar experience, and be thoroughly practical and good organiser. No one at present on Government work need apply.—State age, full experience, salary required, &c., BOX No. 2270, HEYWOODS, 150, Holborn, E.C. 1. J 305

The Engineering Employers'

FEDERATION REQUIRES as technical assistants TWO ENGINEERS with workshop and management experience. Applications, stating age, qualifications, experience and salary required, accompanied by copies of testimonials, should be addressed, marked "Engineers," to the ENGINEERING EMPLOYERS' FEDERATION, 34, Abingdon Street, Westminster, London, S.W. 1. Canvassing by or on behalf of any applicant will disqualify his application. H 880

Shift Engineer Required by

large manufacturing firm under Government Control. Experienced with H.-T. Turbo-Alternators and Lancashire and Water-tube Boilers essential. Good wages. FITTER DRIVER. Good wages. No person already on Government work.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A. 3898. J 117

Engineers of Sound Mechani-

cal training with experience in construction of large Power Stations WANTED Immediately by Government Department for duration of war. Also ELECTRICAL ENGINEERS with experience of latest practice in factory equipment. No person resident more than 10 miles away or already engaged on Government work will be engaged.—Apply, stating age, experience and salary required, to BOX No. 236, CAXTON ADVERTISING AGENCY, Clun House, Surrey Street, Strand, W.C. J 2c2

Works Manager's Assistant

WANTED, for Controlled Establishment, North-West London District. Good opening and permanent position for a man possessing good all-round engineering knowledge. Applicants should have received a thorough training in systematic and efficient factory organisation. No persons more than 10 miles away or engaged on Government work need apply.—Write, stating qualifications and salary, to J 270, Offices of ENGINEERING.

Wanted, for Controlled

Establishment, North-West London District, ASSISTANT WORKS MANAGER or SUPERINTENDENT, for taking entire control of about 1000 workpeople, male and female. The position will be a permanent one, and offers considerable scope for an engineer who is a systematic and capable organiser and has had experience in a somewhat similar position. No persons more than 10 miles away or engaged on Government work need apply.—Write, stating qualifications and salary required, to J 269, Offices of ENGINEERING.

Required, by London Firm,

Man to act as UNDERSTUDY to Manager of machinery department. Must have good practical knowledge of automatic tin box making machines. Able to conduct correspondence, travel, and interview possible buyers, and, when necessary, take entire charge of department during manager's absence. Knowledge of French language not obligatory but desirable, with view of extension of business to France. Disabled Army man, 30 to 35 years of age, would be preferred.—Write, stating full particulars as to experience and salary required, to AUTOMAC, care of DEACON'S, Leadenhall Street, London, E.C. 3. J 251

Required, in Government

Factory, METALLURGICAL CHEMIST, for analysis of ferrous and non-ferrous alloys. Previous experience preferable but not essential. Men already on Government work need not apply.—Apply, giving full details of experience and salary required, to the nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 3865. J 160

Required, in Government

Factory, for work in connection with Aeroplanes and Aeroplane Engines, several YOUNG MEN with scientific engineering training. Previous experience of aeroplanes not essential. Men already on Government work need not apply.—Send full details of experience and salary required to your nearest EMPLOYMENT EXCHANGE and quote reference number A 3859. J 163

Inspectors of Aircraft Metal

Fittings, &c., REQUIRED for Government Controlled Aircraft Factory. Apply, stating age, experience, and salary required, through nearest EMPLOYMENT EXCHANGE. No one already on Government work can be engaged.—Please mention this paper and J 264.

Capable Engineering Assis-

TANT WANTED for busy professional man. Must have initiative, and accustomed to organize correspondence. Secretarial qualifications a consideration.—Address, J 246, Offices of ENGINEERING.

Wanted, Technical Assistant

for Power Plant Work; age about 23.—Applications, stating age, qualifications, experience and salary required, accompanied by copies of testimonials, should be addressed to J 241, Offices of ENGINEERING.

Wanted, at Once, Assistant.

Ineligible, experienced in the sale of machine tools and small tools. State in confidence, age, experience, salary, when at liberty. No one residing more than ten miles away or already on Government work will be engaged. Application to be made by letter and marked "private," JAMES W. CARR & CO., LTD., 35, Queen Victoria Street, E.C. 4. J 266

Draughtsman.—Wanted, a

good MAN with experience in railway work and factory design to take charge of drawing office.—Address, J 250, Offices of ENGINEERING.

Draughtsman Wanted for

Constructional Works in Midlands. Experienced man desired. State age, salary and full particulars to your nearest EMPLOYMENT EXCHANGE, mentioning ENGINEERING and J 261. No person already on Government work will be engaged.

Draughtsman Required.

Mostly detail work. Experience "Plenum" Heating advantage. Offices Westminster, chiefly engaged Admiralty work. Good salary to suitable man. Immediate. No one living more than 10 miles away or already on Government work will be engaged.—Address, J 255, Offices of ENGINEERING.

Draughtsmen Required, for

service in an Admiralty Department, preferably with experience of marine engineering.—Applicants to state age, salary required, and details of previous experience. Applications to be forwarded to reach BOX No. 1208, care of Messrs. R. F. WHITE & SON, General Advertising Agents, 33, Fleet Street, London, E.C. 4, not later than November 9th. J 276

Experienced Draughtsman for

Reinforced Concrete work WANTED, immediately; London, W. 1. No person already employed on Government work will be engaged.—Address, stating age, experience, and salary required, J 277, Offices of ENGINEERING.

Draughtsmen. — Several

JUNIORS WANTED quickly for Government work in Midland engineering works. Permanent jobs for suitable men.—Apply under reference No. A3960, stating age, experience fully, salary expected, and when at liberty, to your nearest EMPLOYMENT EXCHANGE. No person already on Government work will be engaged. J 267

Wanted, Draughtsman for

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THE WHIRLING OF SHAFTS.

By H. A. Webb, M.A.

§1. Introduction.

The problem of calculating the whirling speed of large turbo-alternators and other turbo-machinery is of considerable practical importance, although it is essentially mathematical in character. The differential equation on which the solution of the problem depends has long been known, but few rigorous solutions, except for the cylindrical shaft, have hitherto been obtained. In the following work an extremely simple graphical method is given, which, it is claimed, gives results within 3 per cent., and in general within 1½ per cent., for non-cylindrical shafts of an extraordinarily wide range.

The range is as follows:—

At any section of the shaft,

Let w = the weight of the shaft per unit length, and
Let I = the moment of inertia of the section in bending;

then the graphical method is valid if

$$\frac{\text{maximum value of I}\,w}{\text{minimum value of I}\,w} < 40{,}000$$

It is believed that all shafts likely to be required in practice will fall within this range.

To establish the validity of the graphical method it has been necessary to find, by rigorous mathematics, a number of new solutions for non-cylindrical shafts, with which the solutions found by the graphical method have been compared.

My acknowledgments are due to Mr. W. H. Barling, A.R.C.Sc., for allowing me to use an approximate method of attacking the general problem, investigated by him some years ago, but hitherto unpublished; on this approximate method the graphical solution is based.

It is hoped that this graphical solution will be of use in design. Those who wish to use it and are content to accept it without proof will find it fully explained in §10 to §12, which, together with the curves in Fig. 9, are intelligible apart from the rest of the paper.

§2. The Mathematical Statement of the Problem.

The shaft in Fig. 1 is freely supported on bearings at its ends O and C, and is a surface of revolution rotating with uniform angular velocity. It is well known that at a certain critical speed the shaft will "whirl"; there may be other, higher, critical speeds, but we are concerned only with the lowest, which we propose to investigate in the following work. We neglect the effect of gravity on the shaft.

L inches = the length of the shaft between the bearings.
p radians per second, or N revolutions per minute = the angular velocity of the shaft.
E lb. per square inch = Young's modulus of elasticity for the shaft in bending.
w lb. = the weight of the shaft per inch length.
I inch units = the moment of inertia of the section in bending, and
y inches = the deflection of the central line of the shaft at the section MM′ distant x inches from O.
Axes O x, O y are taken as in Fig. 1.
w and I are given functions of x.

Then $\mathrm{E\,I}\dfrac{d^2y}{dx^2}$ is the bending moment, and $\dfrac{d^2}{dx^2}\left(\mathrm{E\,I}\dfrac{d^2y}{dx^2}\right)$ is the load per inch length of the shaft, at the section M M′.

This load is centrifugal (as gravity is neglected), and $= \dfrac{w}{g}\cdot p^2 y$ lb. per inch length, where g inches per second per second is the acceleration due to gravity.

$$\therefore \frac{d^2}{dx^2}\left(\mathrm{E\,I}\frac{d^2y}{dx^2}\right) = \frac{w}{g}\cdot p^2 y \quad . \quad . \quad (1)$$

is the differential equation of the deflected central line of the shaft.

The solution of this differential equation involves four arbitrary constants, which are to be determined from the four terminal conditions

$$\left.\begin{matrix} y = 0 \\ \text{and } \dfrac{d^2y}{dx^2} = 0 \end{matrix}\right\} \text{ at } \left.\begin{matrix} x = 0 \\ \text{and } x = \mathrm{L} \end{matrix}\right\}$$

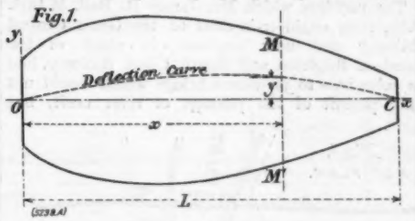
since at both ends the deflection and the bending moment are zero.

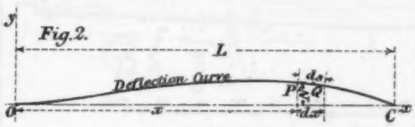
From the form of (1) it is clear that—*either* all the constants of integration are zero, *i.e.*, there is no deflection anywhere, and the central line remains straight, *or* we can eliminate all the constants of integration, obtaining an equation for p. For the value of p so found the constants of integration are indeterminate, and the shaft deflects to any indeterminate extent. We infer that to run at this value of p is dangerous. This value of p is the whirling speed.

For a shaft of uniform section *i.e.*, a cylindrical shaft, the solution is well known, and is given in Perry's "Applied Mechanics," chapter xxi, and in Morley's "Strength of Materials," chapter xiv.

For a shaft of non-uniform section I and w are functions of x, and the solution of (1) presents considerable mathematical difficulty, and does not lend itself conveniently to graphical methods for practical work.

It may be noticed that the problem of finding the period of free lateral vibrations of the shaft, discussed in Rayleigh's "Theory of Sound," second edition, vol. i, chapter viii, but not solved there except for the case of a cylindrical shaft, leads to the same differential equation, with the same terminal conditions, and consequently to the same





solution, as the problem of finding the whirling speed of the shaft. We shall regard the two problems as identical.

Stodola, "Steam Turbines," second edition, pages 351 to 355, discusses the problem, but unfortunately starts with the wrong differential equation—he takes $\mathrm{E\,I}\dfrac{d^4y}{dx^4}$ instead of $\dfrac{d^2}{dx^2}\left(\mathrm{E\,I}\dfrac{d^2y}{dx^2}\right)$—so that his conclusions are unsound.

For a short shaft a small correction due to rotary inertia may be required. This will be discussed later, §9.

The following approximate solution of the problem, from the point of view of lateral vibrations, was investigated some years ago by W. H. Barling, A.R.C.Sc.

§3. Barling's Hypothesis.

Lateral Vibrations of a Shaft.—The potential energy of an element P Q (ds) of the shaft (Fig. 2)

$$= dV = \frac{1}{2}\,\mathrm{M}\,.\,d\theta, \text{ where M is the bending moment,}$$
$$= \frac{1}{2}\cdot\frac{\mathrm{E\,I}}{\mathrm{R}}\cdot\frac{ds}{\mathrm{R}}$$
$$= \frac{1}{2}\cdot\mathrm{E\,I}\left(\frac{d^2z}{dx^2}\right)^2\cdot ds \text{ inch-lb.}$$

The kinetic energy of the element P Q

$$= dT = \frac{1}{2}\cdot\frac{w}{g}\cdot\left(\frac{dz}{dt}\right)^2\cdot ds \text{ inch-lb.}$$

and $ds = dx$ approximately. (Fig. 2.)

$$\therefore \frac{1}{2}\int_0^{\mathrm{L}}\mathrm{E\,I}\left(\frac{d^2z}{dx^2}\right)^2\cdot dx + \frac{1}{2}\int_0^{\mathrm{L}}\frac{w}{g}\cdot\left(\frac{dz}{dt}\right)^2 dx$$

= the total energy of the shaft, and is therefore a constant, independent of the time.

Barling's hypothesis is that

$$dV + dT,$$

i.e.,

$$\frac{1}{2}\left\{\mathrm{E\,I}\left(\frac{d^2z}{dx^2}\right)^2 + \frac{w}{g}\left(\frac{dz}{dt}\right)^2\right\}dx,$$

is independent of the time; or, in other words, that there is no transference of energy between consecutive elements of the shaft. Such a transference, if it took place, would be produced largely by shear, the shearing forces, by doing work, altering the shape of the deflection curve. But we know from experience that in a long shaft the deflection due to shear is small compared with the deflection due to bending moment. Further, in a cylindrical shaft, Barling's hypothesis gives, as we shall see, the correct result. It seems, therefore, not unlikely that it will give results not far from the truth in other cases.

Adopting Barling's hypothesis, we find that

$$\mathrm{E\,I}\left(\frac{d^2z}{dx^2}\right)^2 + \frac{w}{g}\left(\frac{dz}{dt}\right)^2$$

is independent of the time.

Now

$$z = y\sin p\,t,$$

where y is the amplitude of the vibration of P.

$$\frac{d^2z}{dx^2} = \frac{d^2y}{dx^2}\sin p\,t,$$

and

$$\frac{dz}{dt} = y\,p\cos p\,t.$$

$$\therefore \mathrm{E\,I}\left(\frac{d^2y}{dx^2}\right)^2\sin^2 p\,t + \frac{w}{g}\cdot y^2 p^2\cos^2 p\,t$$

is independent of the time.

Differentiate with respect to t.

$$\therefore 2\,\mathrm{E\,I}\,p\left(\frac{d^2y}{dx^2}\right)^2\cdot\sin p\,t\cdot\cos p\,t - \frac{2w}{g}\cdot y^2 p^3\cdot\sin p\,t\cdot\cos p\,t = 0$$

$$\therefore \mathrm{E\,I}\left(\frac{d^2y}{dx^2}\right)^2 = \frac{w}{g}\cdot y^2 p^2.$$

$$\therefore \sqrt{\mathrm{E\,I}}\,\frac{d^2y}{dx^2} = \pm y p\cdot\sqrt{\frac{w}{g}}.$$

For the slowest period of vibration it is seen from Fig. 2 that y and $\dfrac{d^2y}{dx^2}$ are of opposite signs.

$$\therefore \frac{d^2y}{dx^2} + p\,y\sqrt{\frac{w}{g\,\mathrm{E\,I}}} = 0 \quad . \quad . \quad (2)$$

It is seen from (2) that when y vanishes $\dfrac{d^2y}{dx^2}$ also vanishes. Hence the four terminal conditions reduce to two, viz.:

$$\left.\begin{matrix} y = 0 \text{ when } x = 0 \\ \text{and when } x = \mathrm{L} \end{matrix}\right\}$$

The solution of (2) contains two arbitrary constants. The two terminal conditions give two equations, from which, by eliminating the two arbitrary constants, we obtain an equation for p.

§4. Estimate of the Error Arising from Barling's Hypothesis.

Assume, as in (2), that

$$\frac{d^2y}{dx^2} + p\,y\sqrt{\frac{w}{g\,\mathrm{E\,I}}} = 0$$

$$\therefore \mathrm{E\,I}\frac{d^2y}{dx^2} + p\,y\sqrt{\frac{w\,\mathrm{E\,I}}{g}} = 0$$

$$\therefore \frac{d^2}{dx^2}\left(\mathrm{E\,I}\frac{d^2y}{dx^2}\right) + p\sqrt{\frac{\mathrm{E}}{g}}\cdot\left\{\sqrt{\mathrm{I}\,w}\cdot\frac{d^2y}{dx^2} + 2\left[\frac{d}{dx}\sqrt{\mathrm{I}\,w}\right]\cdot\frac{dy}{dx} + \left[\frac{d^2}{dx^2}\sqrt{\mathrm{I}\,w}\right]\cdot y\right\} = 0$$

$$\therefore \frac{d^2}{dx^2}\left(\mathrm{E\,I}\frac{d^2y}{dx^2}\right) - \frac{w}{g}\cdot p^2 y = -\,p\cdot\sqrt{\frac{\mathrm{E}}{g}}\cdot\left\{2\left[\frac{d}{dx}\sqrt{\mathrm{I}\,w}\right]\cdot\frac{dy}{dx} + \left[\frac{d^2}{dx^2}\sqrt{\mathrm{I}\,w}\right]\cdot y\right\} \quad (3)$$

which is zero if $\sqrt{\mathrm{I}\,w}$ is constant; so that, if $\sqrt{\mathrm{I}\,w}$ is constant, the equation (1) reduces to equation (2), and Barling's hypothesis is correct. The cylindrical shaft is a special case in which $\sqrt{\mathrm{I}\,w}$ is constant.

If $\sqrt{\mathrm{I}\,w}$ is not constant, the error seems to depend on $\dfrac{d}{dx}\sqrt{\mathrm{I}\,w}$.

It will appear later that an additional correction is required when the centre of gravity of the shaft is not midway between the bearings.

The equation (2) is soluble mathematically in many more cases than equation (1); also a rapid and convenient graphical method of solving equation (2) will be given later, §10. But the value of p found from (2) is not mathematically correct, except

for a shaft in which $\sqrt{I\,w}$ is constant. If, however, the error is small, and if we know its magnitude approximately, we can, by solving (2) and making a correction for the error, find a value of p which is accurate enough for all practical purposes.

We will therefore solve the whirling problem accurately for certain cases by solving equation (1). We will then solve it for the same cases on Barling's hypothesis by solving equation (2), and compare results.

Empirical Rule.

It will be found that the following empirical rule gives results correct within 1 per cent. for all the cases to be considered in this paper:—

Let e inches = the eccentricity of the centre of gravity of the shaft, *i.e.*, the distance from the centre of gravity to the point midway between the bearings.

Let R = the average *numerical* value of $\frac{d}{dx}\sqrt{I\,w}$ along the shaft; by "numerical" value we mean that $\frac{d}{dx}\sqrt{I\,w}$ is always to be considered *positive*.

Let S = the average value of $\sqrt{I\,w}$ along the shaft.

Subtract $\left\{3500\left(\frac{e}{L}\right)^3 + \frac{5}{9}\cdot\frac{L^2R^2}{S^2}\right\}$ *per cent.* of the whirling speed found on Barling's hypothesis: this gives the true whirling speed within 1 per cent.

It may be noticed that if $\sqrt{I_1 w_1}$, $\sqrt{I_2 w_2}$, $\sqrt{I_3 w_3}$, $\sqrt{I_n w_n}$, are the successive maxima and minima of $\sqrt{I\,w}$ along the shaft, including the two ends,

$$L\,R = \pm\{\tfrac{1}{2}\sqrt{I_1 w_1} - \sqrt{I_2 w_2} + \sqrt{I_3 w_3} - \ldots \pm \tfrac{1}{2}\sqrt{I_n w_n}\}.$$

For a practical shaft the curve for $\sqrt{I\,w}$ should be "smoothed" before R and S are calculated —*i.e.*, the curve should be replaced by a fair curve containing no sharp angles.

(To be continued.)

Salving the "Peking."—Some six months ago the Swedish East Asiatic Company's steamer Peking, on a homeward trip from the East, got on fire in the Suez Canal and capsized. The ship was left lying on her side with several feet of water over all. The Svitzer Salvage Company, Copenhagen, whose salvage steamer Protector has for some years past been stationed in the vicinity of the place where the accident happened, contracted with the insurance companies for salvage. The terms agreed to were that the salvage company was to have 50 per cent. of the cargo and ship. The cargo, consisting of 6,000 tons of copra, was discharged by removing some plates from the ship's side and dried on shore, realising on sale some £111,000. After being thus lightened the hull was again made good, and the salvage proper commenced. Within a month the boat had been conveyed to water deep enough to allow of her being righted. She was then pumped dry and taken to Suez, where the necessary repairs can be undertaken, after which the Peking will probably be worth some £360,000, so that the Svitzer Company may expect to receive upwards of £220,000.

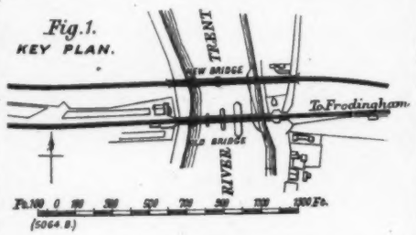
The Shortage of Fuel in Switzerland.—The shortage of fuel threatens to develop into a famine in some neutral countries, and the danger is being met in two ways, viz., by stringent official restrictions as to the uses of fuel, direct or indirect, and an increased exploitation of existing home supplies. Switzerland has perhaps felt the inconvenience more than most other countries, and the Government of the Canton of Zürich, for one, has just issued fresh restrictions. Private houses must not be heated, unless the temperature for three consecutive days has been below 10 deg. C. and on days when it has been only 5 deg. C. the previous evening. The temperature in residences, schools, offices and workshops is not to exceed 16 deg. C., in shops not above 14 deg. C., and in bedrooms not above 12 deg. C. Hot water appliances must only be used once a week and school baths only once a month. Other public baths may in the meantime be kept open except on Mondays and Tuesdays. In cafés, restaurants, &c., there must be no heating from 10 p.m. to 10 a.m., and no hot food must be served after 9 p.m. All offices are to close at 5 p.m. and museums, libraries, &c., must not be warmed at all. The schools are to save 35 per cent., churches and chapels 50 per cent., cafés and restaurants 35 per cent., shops and public buildings 25 per cent., elsewhere according to circumstances from 20 per cent. to 40 per cent. of the quantities of fuel hitherto used. In four-roomed residences only one room must be heated, in larger residences only two. On the other hand endeavours have quite recently been started to exploit possible deposits of coal, lignite, and even petroleum, but this work is still in its first stages. Borings for coal are taking place in Wallis and Jura, at Herdern, &c.; lignite deposits have been taken in hand at Gondiseril, Uffhusen and Zell; lignite has also been come upon at Fösytal. Some foreign capital is interested in this work, as, for instance, in the International Development Associated Mines Company, at Sitten, for the exploitation of the Wallis deposits, where some anthracite, though not of the best quality, has been found.

KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE.

When this bridge* was opened for public traffic last year we published a general description, illustrated by perspective views,† and we now commence in this issue the publication of complete drawings. These are interesting from the engineering point of view, as the roller lift span weighs with its counterweight about 2,900 tons, and is the largest yet built, and also because of the problems involved in the general question of design, owing to the difficulties of the site. From the general point of view, too, the structure is important, as it anticipates the traffic requirements due to the development of an important area of the East Coast of England.

The Keadby Bridge carries the main line traffic from Liverpool, Manchester and Sheffield and heavy coal traffic from the South Yorkshire coalfields to the ports of Immingham and Grimsby across the River Trent, about 14 miles north of Gainsborough. It replaces an old swing railway bridge, which, in view of the completion of Immingham Docks, was considered to be insufficient for the heavy loads involved.

The problem which Mr. James B. Ball, M.Inst. C.E., then engineer-in-chief of the Great Central Railway and now engineer-in-chief of the London, Brighton and South Coast Railway, had to solve was to provide a bridge which would not only permit of the passage of river craft, but



Plan showing Relative Positions of the Old and New Bridges.

ensure the minimum of interruption to the railway traffic. In the first place the site was at a bend of the river, and the tidal current, which sometimes is about 9 knots, rendered navigation difficult, if not dangerous, several accidents having occurred in former days. The old bridge, which was slightly further up the river, had an opening swing span, which gave a passage on each side of the dolphin and pier of 60 ft., and a minimum height over the waterway of 13 ft. 1 in. Mr. Ball's aim was to improve these conditions, first as regarded the width of channel in the opening span, so as to simplify the passage of craft, and, secondly, to increase the headway, in order to pass the majority of vessels navigating the Trent without opening the bridge, thus securing greater continuity of railway connection.

After careful consideration, and after making a visit to the United States in order to study the various methods adopted in tackling similar problems there, particularly by the use of the Scherzer roller lift span, Mr. Ball decided to recommend the adoption of such an opening span. In this way he was able to give a clear channel of 150 ft. in width. He arranged his gradients of approach to the bridge so as to give a headway of 16 ft. Moreover, as the opening span could be built in a vertical position, he was able to construct the bridge without interfering in any way with navigation on the Trent during the operation of building the bridge.

The bridge confers a great advantage on the agricultural and industrial community, as, in addition to a double railway track, it carries a public highway, which eventually will form the main road leading from Doncaster and South Yorkshire across the Trent to Scunthorpe, Grimsby and the north-west portion of Lincolnshire. At present the roads leading to the bridge from each direction are not, within a radius of about 6 miles, well adapted for modern fast motor traffic. The respective District Councils concerned, however, have schemes under consideration for strengthening the bridges and forming new roads where necessary; only the present conditions arising from the war prevent these improvements from being carried through. The new highways will materially assist in the development of the north-west portion of Lincolnshire, particularly the Scunthorpe district. In fact, if we except the slow and sometimes dangerous ferries, the latter town is brought thereby some 20 miles nearer to Doncaster. The next road bridge is at Gainsborough, 14 miles up-stream. Down-stream there are no bridges and no substantial means of crossing until the steam ferry between Hull and New Holland is reached.

The new bridge is situated 200 ft. north, or down-stream, parallel to the old bridge. Fig. 1, on the present page, shows the relative positions and approaches of the two bridges, while Figs. 2 and 3, on page 457, are an elevation and plan of the old bridge and Figs. 4 and 5 corresponding views of the new bridge, both the elevations being views looking down-stream. The old bridge was built by Fairbairn, and was opened to traffic in 1861. It consists of four fixed spans, with a swing span over the main river channel giving a passage, as we have already said, 60 ft. clear for the traffic on each side of the centre pier and dolphin. The main girders are continuous double-webbed plate girders resting on cast-iron cylinders braced together. The floor system consists of cross-girders, built up of top and bottom angles and a web-plate, spaced 3 ft. apart, centre to centre, on which rest oak way beams. The bridge, as will be seen from the views given, is of the half-through type, and there is no diagonal wind bracing. The swing span, as first designed, was operated by hand, but later steam power was installed. The overall length of the bridge between abutments is about 470 ft.

The new structure, a combined railway and road bridge, has four fixed spans and one lifting span. The overall length of the bridge between faces of abutments is 548 ft. Road approaches leading up to the bridge are constructed on each side of the river, that on the east side having a gradient of 1 in 25, while that on the west side has a gradient of 1 in 30. The four piers, and the east and west abutments, are built of blue brick and grey Norwegian granite backed with concrete. The four piers rest on steel caissons. The abutments rest on piled foundations and upon beds of concrete 6 ft. thick. The total weight of steelwork in the bridge is 2,760 tons, in addition there were 590 tons of steelwork in the caissons. The main river channel, it will be noted, is on the east side, and the piers of the new bridge on each side of this channel (piers Nos. 2 and 3) are placed in line with the dolphins of the old bridge.

The designs were prepared and the whole of the work carried out under the supervision of Mr. Ball, while his assistant on the Great Central Railway staff—Mr. A. G. Gardner, Assoc.M.Inst.C.E.—was responsible for the calculations for the work in the drawing office. Mr. D. Carson was the resident engineer.

The construction of the bridge was entrusted to Sir William Arrol and Co., Limited, Glasgow, who have built so many Scherzer roller-lift spans in this country, and the late Mr. Andrew S. Biggart, chairman of the company, took a close and active part in carrying out this work, as in the other important undertakings of the company; as did also Mr. Adam Hunter, one of the directors. The firm's resident engineer was Mr. J. H. Nicholson, Assoc.M.Inst.C.E., to whom we are indebted for the notes for this description of the undertaking.

Borings taken at the site previous to the contract being let indicated that the top of the Keuper marl bed of the old pre-glacial river occurred from 43 ft. to 46 ft. below low water, and the piers were designed to be founded on the marl at 50 ft. below low water. The successful founding of all the caissons at this level amply proved the accuracy of the borings.

The first proceedings in connection with the

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* A paper on the Keadby Bridge, by Mr. James Benjamin Ball, M.Inst.C.E., was read before the Institution of Civil Engineers on November 21, 1916, and this paper, with the discussion thereon, will appear in vol. 203 of the Proceedings of the Institution.

† See Engineering, vol. ci, page 592.

erection of the bridge was the drawing of the old piles driven in the site of No. 4 caisson and the construction of a staging on which this caisson was to be built. Later, this staging was extended for the sinking of No. 3 caisson, and finally was raised and served for the erection of the track span. Concurrently with the sinking of No. 4 caisson a temporary stage was built out from the west bank into the river to the site of pier No. 1. Later, this was extended out to the site of pier No. 2, thereby closing the river to traffic, except for the clear passage opposite the swing span of the old bridge and over the site to be bridged by the roller-lift span. There was frequent traffic of barges past the bridges, which might be divided into two classes—of "slow" traffic, covering sailing and drifting barges, and "fast" traffic, consisting of strings of barges towed by powerful steam tugs, with occasional vessels engaged in the coasting trade. At the request of the river authorities and the Board of Trade a steam tug was in constant attendance, night and day, to assist vessels requiring its aid in navigating through the openings of the two bridges, and no accidents occurred to vessels during the progress of the work. The temporary stages from the west bank were carried out for the full width of the bridge, and, later, were increased in height and served as stagings for the erection of the steel superstructure, Figs. 6 to 10, on page 458, showing successive steps in the development of this staging.

The piles of this temporary staging were pitched 18 ft. apart, and were braced diagonally by 11-in. by 4-in. timbers. At the sites of caissons Nos. 1 and 4, and at the erection dock for caissons Nos. 2 and 3, four groups of double piles were driven. On these, double crossheads were placed which carried transverse steel built-up girders. On these girders rested the four hydraulic jacks by means of which the caisson was lowered to the river bed. The piles of the stagings were 12 in. by 12 in., while those for the lowering trestles were 13 in. by 13 in. On the piles single crossheads were laid which supported 12-in. by 12-in. longitudinal timbers covered by planking.

The main dimensions of the four pier caissons, with their respective positions, are as follow:—

Designation.	Size.	Position.
No. 1 Caisson	86 ft. 6 in. long by 18 ft. wide by 31 ft. high	Supporting fixed spans Nos. 1 and 2.
No. 2 Caisson	86 ft. 6 in. long by 18 ft. wide by 26 ft. 6 in. high	Supporting fixed span, No. 2, and nose end of lifting span.
No. 3 Caisson	94 ft. long by 20 ft. wide by 32 ft. high	Supporting track span of lifting span next river.
No. 4 Caisson	87 ft. 8 in. long by 18 ft. wide by 31 ft. high	Supporting track span next flood bank.

The caissons are rectangular and are built up

Fig. 2. ELEVATION OF OLD SWING BRIDGE.

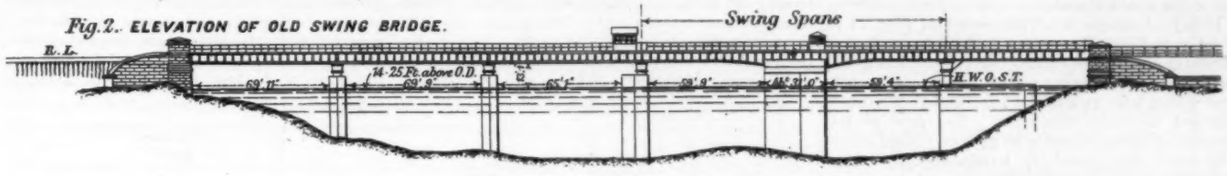


Fig. 3. PLAN OF OLD SWING BRIDGE.

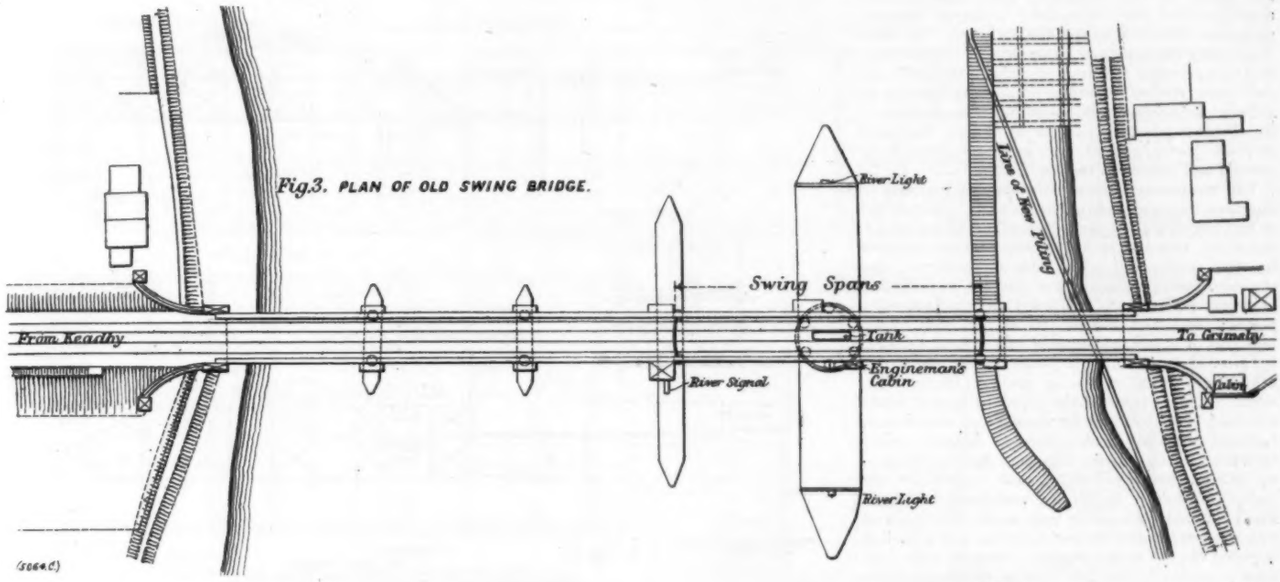


Fig. 4. ELEVATION OF NEW LIFT BRIDGE.

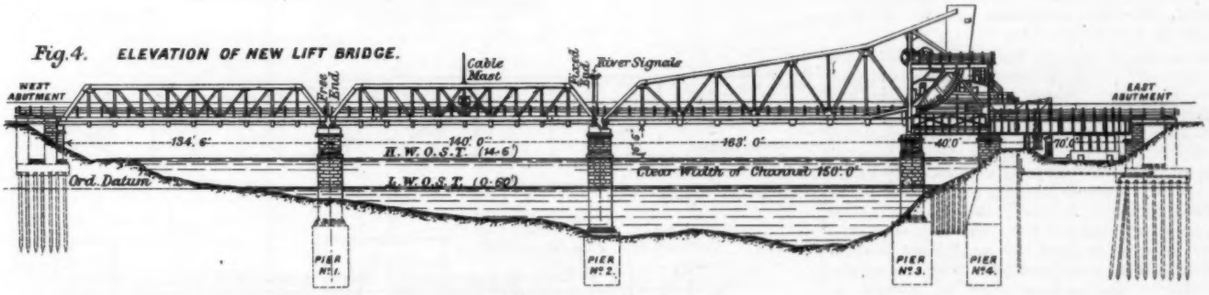
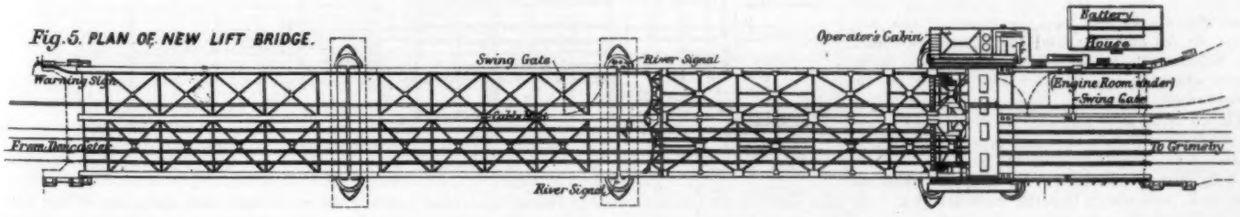


Fig. 5. PLAN OF NEW LIFT BRIDGE.



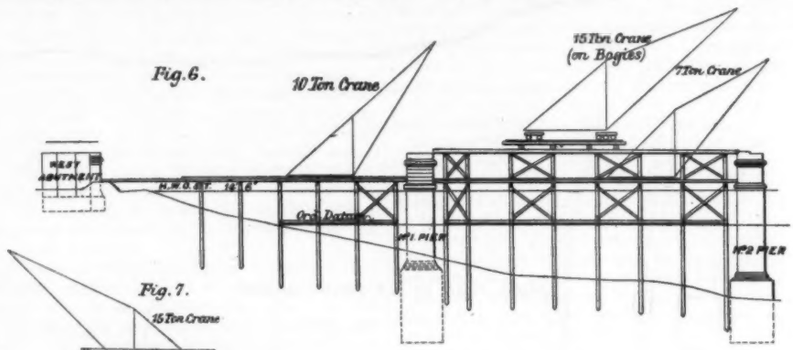
of steel plates ranging from ½-in. thickness in the bottom strakes to ⅜ in. in the upper strakes. The working chambers were 8 ft. 3 in. high, and provided with two shafts for the use of the men and also for the withdrawal of the spoil. Compressed air was admitted to each chamber through a back-pressure valve placed in the man lock situated at the top of one of the access shafts.

Details of caisson No. 2 are shown on Figs. 11 to 17 on page 459. These may be taken as typical of all four caissons. The cutting edge, shown in Fig. 14, consisted of a thickening plate 1 ft. 5 in. deep, stiffened with a 6-in. by 6-in. by ⅞-in. angle. To this is attached the inner skin plate. The roof of the chamber is strengthened with girders, spaced about 4 ft. apart throughout the length and, below the ends of the girders, triangular diaphragms strengthen the sides of the chamber. The caissons were constructed in the contractors' works in Glasgow, and were delivered to the site by rail. The shoe, comprising the inner and outer skins, with the triangular diaphragms forming the sides of the chamber, were sent riveted together in as large pieces as railway facilities would permit. The weight of the largest piece was about 8½ tons. The roof and side plates, girders, &c., were sent loose, to be erected and riveted at the site.

The temporary caisson—the section required to augment the height of the main caisson where it had to be sunk to a great depth below the water-level in the river—was of a rather unusual pattern, designed by the contractors. The object aimed at was standardisation as far as was possible in this class of work. The units consisted of the following pieces: standard panels, 20 ft. by 4 ft., each built up of a ⅜-in. steel plate and a 3-in. by 3-in. by ⅜-in. angle, forming a flange around the same. Standard vertical stiffening girders, 12 ft. long, when bolted to three of the standard panels, made a section 20 ft. by 12 ft. for the sides of the caisson. Latticed stiffening girders formed distance pieces between the sides of the caisson. Special making-up panels were required for each caisson for the ends and to make up for the variations in length. The joints between panels were made with red lead and spun yarn, and timber strutting was added as required by the water pressure. Special long bolts were provided so that the bottom strakes could be removed, after the completion of the masonry, without the services of a diver.

The method of lowering the caisson corresponded with that adopted by the same firm at the widening of the Blackfriars bridge over the Thames, and illustrated in ENGINEERING, vol. xcix, page 565. At Keadby four hydraulic jacks were supported on steel cross-girders resting on timber trestles as stated above. These jacks were located exactly over lowering brackets, forming part of two of the stiffening girders in the roof of the chamber. Four links passed through the jacks and were connected to the lowering brackets by steel bolts 5 in. in diameter. The links had slot holes at regular intervals, so that cotters could be inserted to support the links with their load on a crosshead on the jack at any height. The pitch of the cotter holes was a little less than the stroke of the ram, 18 in. in the one case, and 18¼ in. in the other, the difference allowing the lower cotter to be removed after the upper cotter had landed on the crosshead of the jack.

The air locks were made by Sir William Arrol and Co., and were of their standard type. A shaft 3 ft. in diameter led upward from the working chamber to well above water-level. To this was fixed the man lock, and above this the material lock, with the overhead gear for lifting the buckets out of the lock. The man lock consisted of two chambers, the material lock was on the same principle, but the doors were horizontal in place of being vertical, The doors were fitted with interlocking gear, so that when a full bucket was raised the outer door could not be opened until the inner door had been closed. By means of a system of signals the raising and lowering of the bucket was entirely under the control of the sinkers inside the caisson, so that any danger from a bucket being lowered when a man was leaving or entering the chamber was obviated. The doors of material locks were manipulated by rack and pinion gear, actuated by a hand wheel. The buckets were raised and lowered by electric winches, placed outside the chamber, the winding drum shaft passing through an airtight gland in the side of the lock. A ladder was placed in the tube for the convenience of the men. Compressed air was supplied by three Arrol compressors, with cylinders 12 in. and 13 in. diameter by 2 ft. stroke, running at 40 r.p.m. Steam was supplied by three semi-locomotive boilers. One compressor was sufficient to supply air to one caisson. The skips used in the locks had a capacity of 8 cub. ft. The maximum output of one set of locks was 160 skips in one shift of 10 hours in sand. This is equivalent to about 40 cub. yards, or 4 cub. yards per hour.



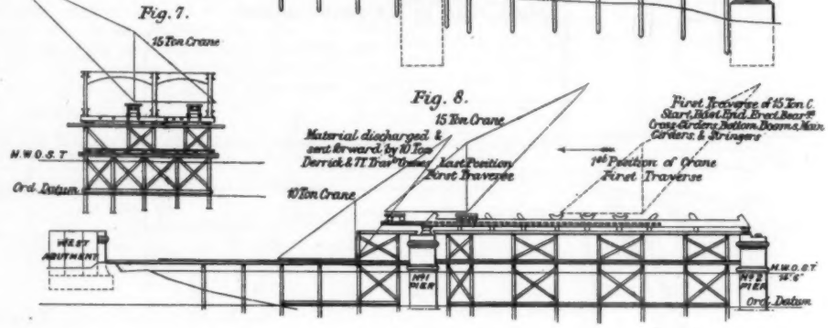


Fig. 7.
15 Ton Crane
Fig. 8.
15 Ton Crane
Material discharged & sent forward by 10 Ton Derrick & 7T Travelling Crane
Last Position First Traverse
1st Position of Crane First Traverse
First Traverse of 15 Ton C. Start, Inlet End, Erect. Rear Cross Girders, Bottom Booms, Main Girders & Stringers
10 Ton Crane
WEST ABUTMENT
N°1 PIER
N°2 PIER
H.W.O.S.T. 18'6"
Ord. Datum

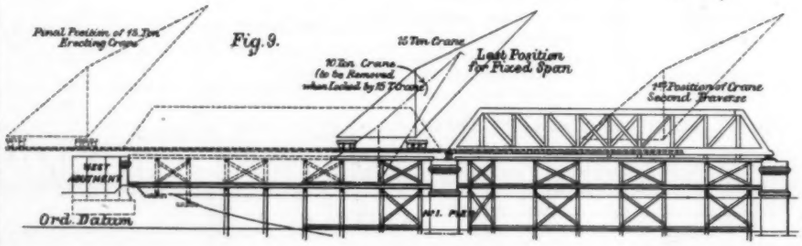


Fig. 9.
Final Position of 15 Ton Erecting Crane
15 Ton Crane
10 Ton Crane (to be Removed when Locked by 15 T Crane)
Last Position for Fixed Span
3rd Position of Crane Second Traverse
WEST ABUTMENT
N°1 PIER
Ord. Datum

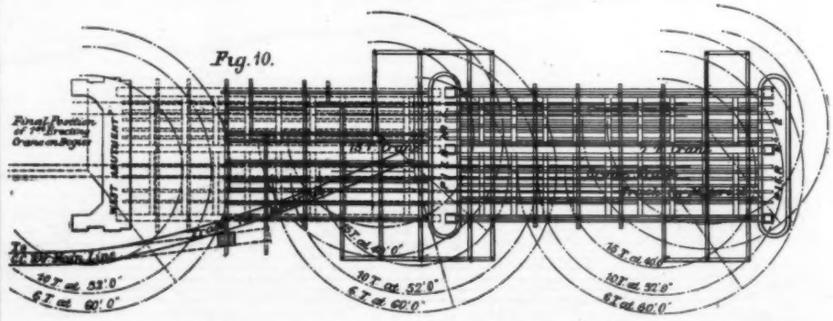


Fig. 10.
Final Position of 7T Erecting Crane on Roller
WEST ABUTMENT
18 T. at 0'0"
10 T. at 53'0"
6 T. at 60'0"
10 T. at 52'0"
6 T. at 60'0"
18 T. at 0'0"
10 T. at 52'0"
6 T. at 60'0"

No. 4 caisson was the first to be sunk. Erection was started on October 8, 1912. The caisson was built above its position on a staging, then lifted by means of four hydraulic jacks, the staging removed, and the caisson lowered to the ground, which had previously been levelled to receive it. The site of the caisson was on the river bank, immediately in front of the flood bank, which for several miles both up and down stream divides the spring tides in the river from the low-lying lands alongside it. The aforementioned levelling of ground resulted in the caisson taking the ground with the cutting edge about 8 ft. above low water. Excavation in the open was started on December 10, 1912, and by January 3, 1913, the caisson had sunk to low-water level and air was put on.

Sinking under air proceeded without interruption until January 28, when the cutting edge had sunk to 13 ft. below low water, and was still in the soft grey mud in which it had started. Great difficulty had been experienced in keeping the caisson in position, and during the two or three days following the latter date, despite all efforts to hold it, the caisson suddenly moved bodily towards the river, a distance in all of 3 ft. 3 in., taking with it the two stools, each consisting of four 13-in. by 13-in. piles, which had been driven to support the lowering girders and as guides to the caisson. Air was at once taken off, the ground behind the caisson removed to low-water level, additional guide piles driven along the river side of the caisson, and, as a further precaution, a row of piles driven behind to take off the pressure of the bank, and anchor piles were driven about 140 ft. back from the river from which the caisson could be anchored. In sinking the first few feet down to low water the cutting edge had passed through a quantity of fascines and brushwood, which seemingly had been placed there when the flood bank had been formed. The subsequent behaviour of the caisson and the

surrounding ground indicated that the weight of the caisson, which at the time of the slip was about 2,000 tons, had completely upset the equilibrium of the bank, always precarious, and caused it to flow toward the river, taking the caisson with it. laying of the brickwork of the pier was started on February 28, and proceeded by tide work until the caisson was founded, at which date the pier had reached a height of 26 ft. 9 in., the top of the brickwork being 7 ft. 9 in. above low water. After- variation in depth, and sandbags were used to make up for such as there was. The depth of water was 12 ft. at low tide and about 26 ft. at high tide. The caisson drew 10 ft. when lowered into the water, so that it rose and fell with the tide. Concrete

Fig. 11. HALF SECTIONAL ELEVATION. HALF OUTSIDE ELEVATION.

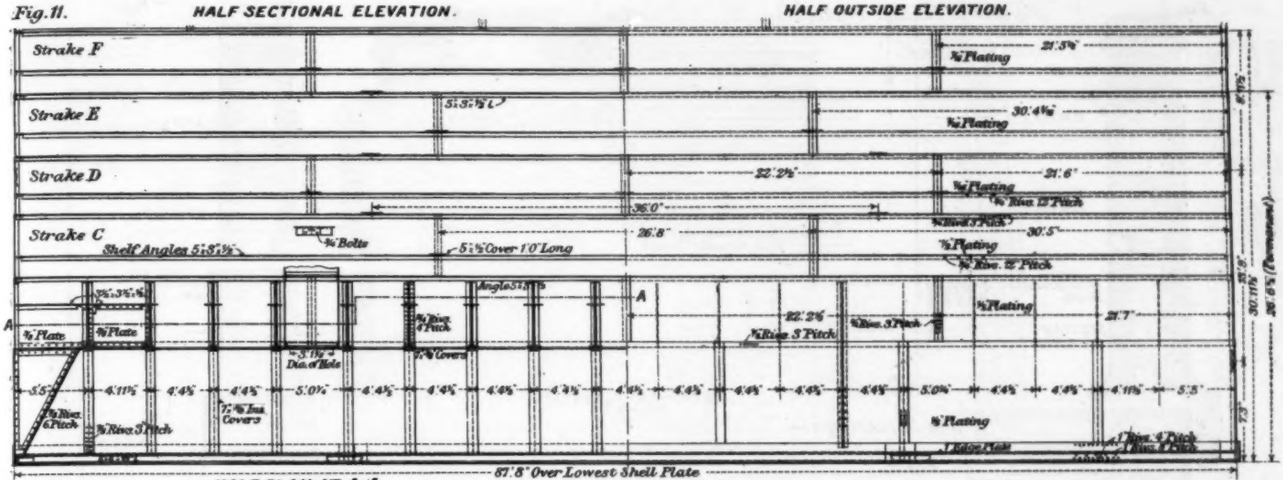


Fig. 12. HALF PLAN AT A.A.

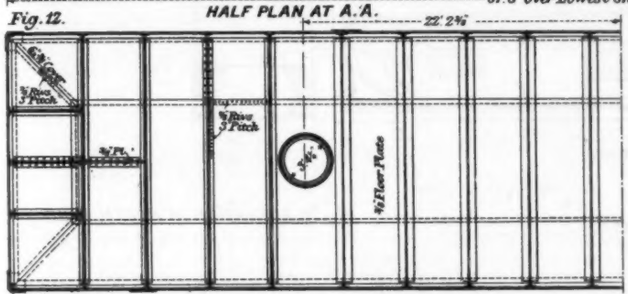


Fig. 13. CROSS SECTION

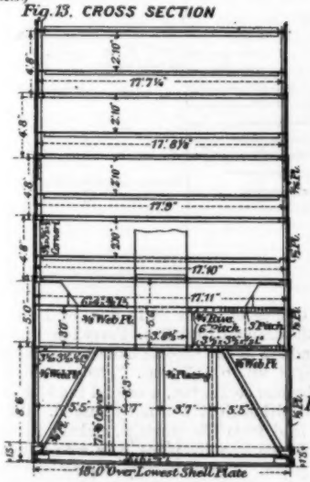


Fig. 14.

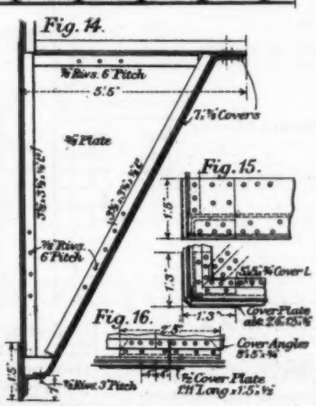


Fig. 15.

Fig. 16.

Fig. 17.

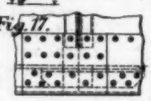
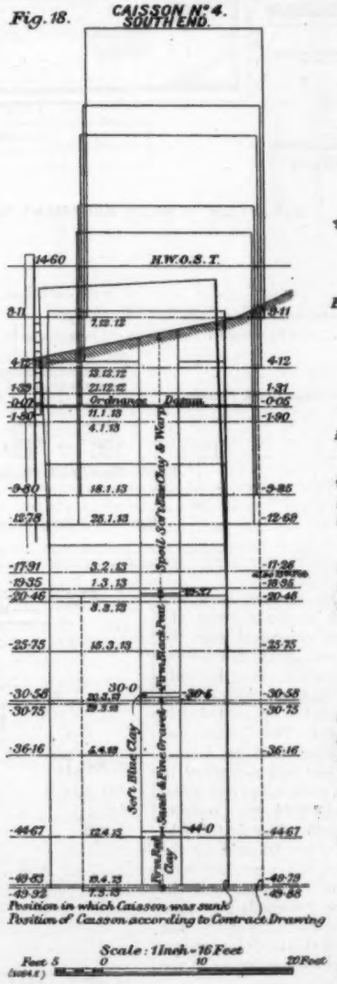
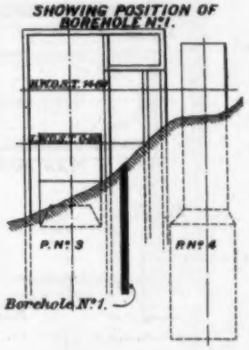


Fig. 18. CAISSON No. 4. SOUTH END.


H.W.O.S.T.
Ordnance Datum
Soft Blue Clay & Warp
Sand & Fine Gravel
Position in which Caisson was sunk
Position of Caisson according to Contract Drawing
Scale: 1 Inch = 16 Feet

SHOWING POSITION OF BOREHOLE No. 1.



BOREHOLE No. 1.

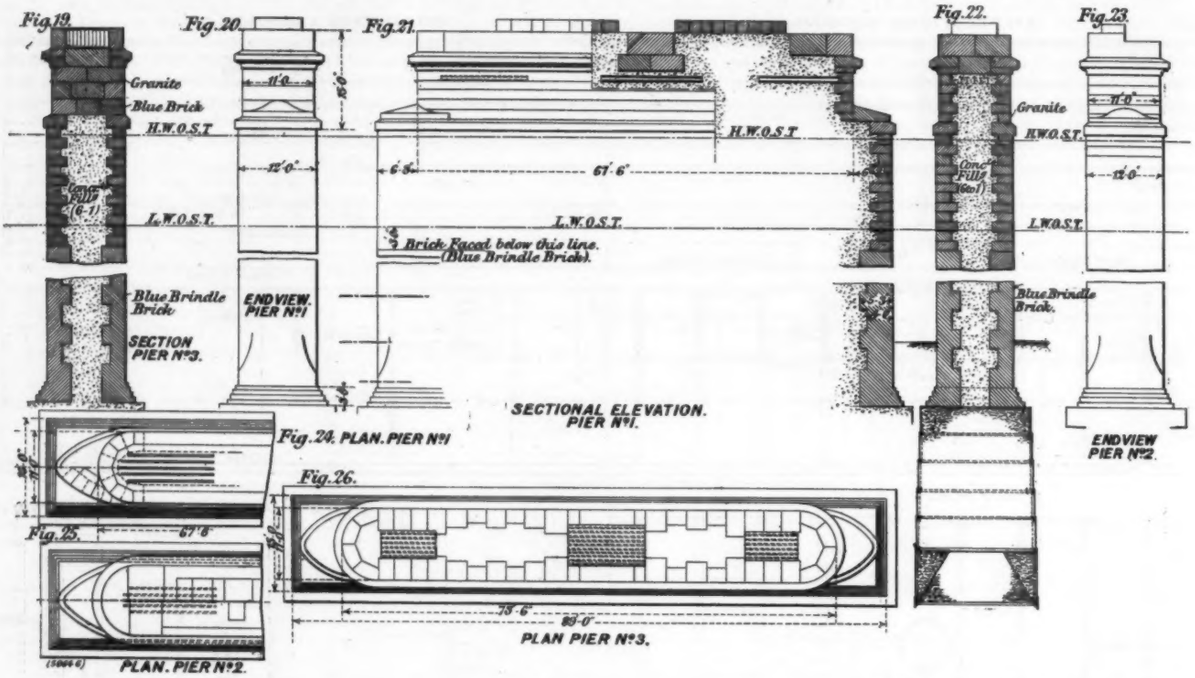
The extent of the movement of the caisson is shown on Fig. 18 on the present page, reproduced from Mr. Ball's paper to the Institution of Civil Engineers.

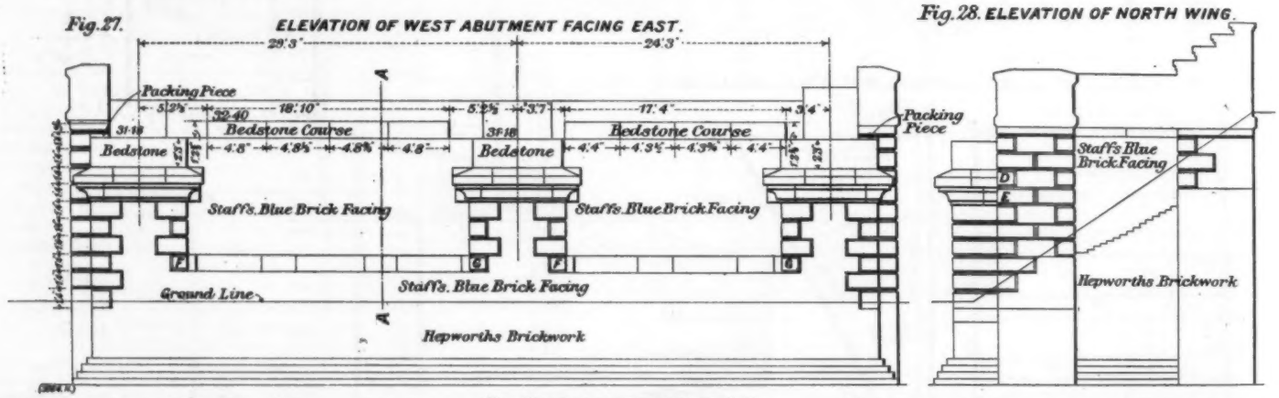
The additional guide and other piles were completed by February 19, when air was again put on and sinking resumed. Fortunately at 21 ft. below low water the cutting edge entered a firm black peat throughout its whole length, and once it was well into this there was little further difficulty. The caisson was brought back to the vertical, although it was still 3 ft. 3 in. out of its true place, and it was founded in that position. After passing through 10 ft. of peat and about 12 ft. of gravel it was founded on a good bottom in the Keuper marl, into which it was carried 6 ft. by May 8. Meantime the design of the pier had been modified to suit the displacement of the caisson, and the caisson having been completely concreted to its upper edge, the wards the building of the pier proceeded until it reached a height of about 18 ft. above low water. Building was stopped at this level to ensure easier access to No. 3 caisson, until the latter was founded.

No. 1 caisson was the second to be sunk. Construction of the temporary staging from the west shore had proceeded simultaneously with the work on caisson No. 4, and on February 19, 1913, the erection of caisson No. 1 was commenced. This also was built over its proper position on staging clear of the water, and was then lifted by jacks, when weighing about 160 tons, and lowered into the water on April 24. Soundings of the site showed little was added as rapidly as possible, and the caisson finally took ground on May 8, when its weight was about 1,000 tons. Concreting was continued until May 26, by which date the weight of the caisson had increased to about 1,500 tons. Air was then put on and sinking commenced. The strata passed through consisted of about 28 ft. of silty sand and

THE KEADBY SCHERZER ROLLER LIFT BRIDGE; PIERS AND ABUTMENTS.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

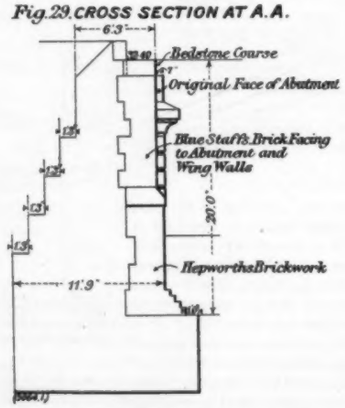




5¼ft. 9 in. of gravel before the Keuper marl was reached. All this was good material from the point of view of sinking, and, combined with the fairly level site, presented no great difficulties. Sinking proceeded without trouble, and the only interruptions were three stoppages required to allow the building to be brought up sufficiently to provide the requisite weight. The caisson was founded 4 ft. 3 in. in the Keuper marl on August 20, 1913. A temporary caisson was necessary in this case, and it was added as sinking proceeded until it reached its full height of 24 ft. Concrete was added as sinking proceeded. The first brickwork of the pier was laid on June 16, and by the time the caisson was founded the pier had been carried up to high-water level. This allowed the temporary caisson to be removed immediately after the caisson was founded. The building of the pier proceeded to a level of about 18 ft. above low water, when this work was stopped to allow access to the site of caisson No. 2.

For reasons connected with the navigation of the river it was thought advisable to postpone the extension of the temporary stages beyond pier No. 1 towards pier No. 2 for as long a time as possible. And in order that no time should be lost it was decided to build caisson No. 2 on a stage alongside the approach stage to pier No. 1, and to float it

Fig.29. CROSS SECTION AT A.A.



out into position. The programme was arranged so that the caisson was ready as soon as the stagings around its site were prepared to receive it. The erection of caisson No. 2 was started July 10, 1913, and it was lowered into the water and floated into position on September 6. The top strake was left off, to keep the caisson as light as possible, so that its floating dimensions were 86 ft. 6 in. by 18 ft. by 22 ft., and the draught 10 ft. 3 in. Forty tons of concrete were added in the shoe as ballast, making the floating weight up to 155 tons. The caisson was towed out by one steam tug, a second tug standing by to assist, although it was not required. Guide ropes were lead from the stagings, and the caisson was finally drawn into its place by a wire rope led to a steam winch. The temporary staging provided consisted of staging and guide piles driven along both sides and across one end of the site, all well braced together. The other end was left open to allow the caisson to enter, and as soon as it was in place logs were fixed across the open end, one row which served as guides to the caisson, and an outer row which acted as fenders against river craft colliding with and damaging the caisson. In addition, four ¾-in. wire ropes were attached to the stagings surrounding the caisson near the ends and carried back to pier No. 1, and the outer row of guide piles were braced to the inner row by timbers passing over the top of the caisson. The staging is shown in the perspective views on Plate XLIV.

Soundings of the site showed the bottom to be sufficiently level for the grounding of the caisson. The depth of water here was 25 ft. at low water and 40 ft. at high water. Concreting was at once commenced, so as to get the caisson grounded without

THE KEADBY SCHERZER ROLLER LIFT BRIDGE; LIFTING SPAN.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

Fig. 30

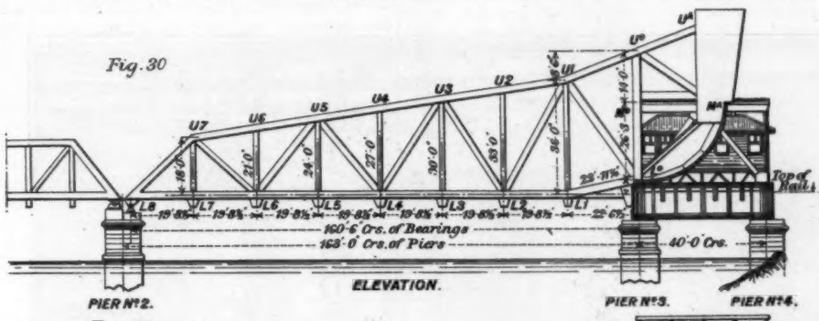


Fig. 31.

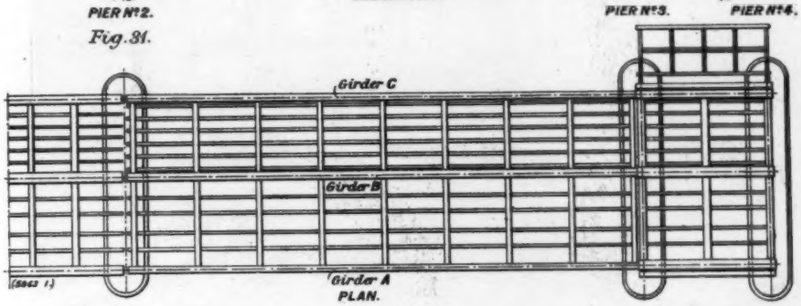
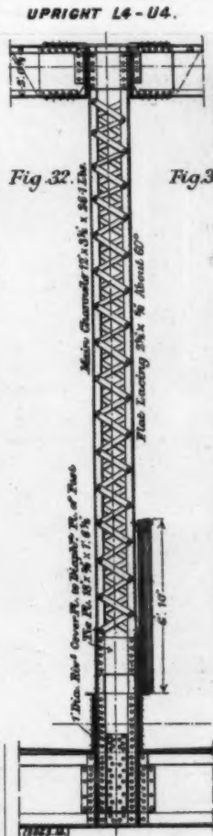


Fig. 34.

UPRIGHT L4-U4.



UPRIGHT L5-U5.

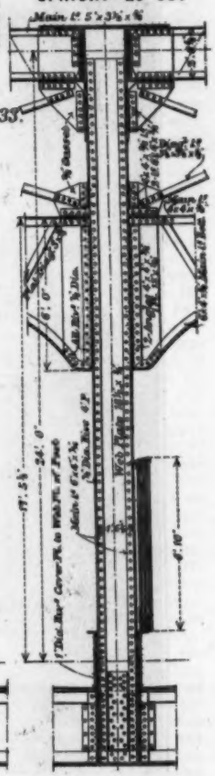


Fig. 32. Fig. 33.

delay. Obviously the permanent caisson was not deep enough to allow this to be done without the addition of the temporary caisson. Five temporary strakes had been added by the time it finally took the ground, making the total depth of the caisson, permanent and temporary, 46 ft. 6 in. It was expected that there might be trouble with this caisson when afloat, due to the strong current of the river, and this period was therefore made as short as possible; this accounts also for the exceptional strength of the staging provided, as already described. Fortunately the precautions taken were sufficient.

The caisson was afloat during a series of spring tides. On one occasion the tide rose 2 ft. 3 in. in the first five minutes of the flood and 4 ft. 3 in. during the first 16 minutes, the total rise of 15 ft. 9 in. occupying three hours. On this occasion there was a bore about 13 in. high. The tide was running at 2½ miles per hour. At this time the caisson weighed 1,000 tons. The caisson finally took the ground on October 10, its weight then being 1,300 tons. The concreting of the caisson was finished and brickwork commenced before sinking was begun. Sinking was commenced on November 3, 1913. After sinking 14 ft. to ensure that the caisson would maintain its position it was levelled and air was released for five weeks, during which time the pier was built up to above high-water level and the temporary caisson removed. Sinking was then restarted, and the caisson was finally founded in marl on February 25, 1914. Building of the pier proceeded at the same time, so that the masonry always was above high-water level. The masonry was then completed up to and including the bed-stones, and the masons afterwards resumed the building of, and finished, pier No. 1.

Caisson No. 3, the last to be dealt with, was built on the same stagings as No. 2, after the latter had been launched. Its erection was started on September 13, 1913, and it was completed ready for floating about the middle of November. Three strakes of plates were left off for lightness, so that the floating dimensions were 94 ft. by 20 ft. by 19 ft. 6 in. high. Forty tons of concrete were deposited in the shoe as ballast, making the total floating weight about 150 tons. The staging around the site was prepared in a similar manner to that for caisson No. 2. Soundings showed that there were great irregularities in the level of the site, the leading features of which was an average cross slope towards the river of about 1¼ to 1, which extended below the river until it reached a depth of 32 ft., and a diagonal slope from the north-east to the south-west corner, with a total fall of 15 ft. At low water the depth of water varied from 4 ft. to 19 ft. The site was partly covered by a portion of the protection dolphin of the old bridge, and after this had been removed and the guide piles driven, the first operation was to level the site. This was effected with a Coles grab suspended from a derrick crane standing on pier No. 4. The high parts were grabbed off and deposited in the low parts until a rough average level was made at about 14 ft. below low-water level. The dredging was carried about 8 ft. outside the site towards pier No. 4, and in the initial stages of the sinking periodical soundings were made along this side of the caisson, and, when necessary, dredging was continued to prevent a bank forming behind the caisson, which would have had the tendency to force it riverwards.

The site was prepared and the caisson was floated into position on November 14. Concreting was at once started; the upper strakes of the plates and the temporary strakes were added as required, and the caisson finally took the ground on December 12. Air was put on and sinking started on January 7, 1914, after the Christmas holidays. Sinking then proceeded, together with the addition of concrete and masonry as in previous piers, without interruption until the caisson was founded on May 16. The strata passed through were similar to those in caisson No. 4. The caisson bore heavily on the guide piles next to the river during the initial stages of sinking, but these were sufficient in number, and due to this and to the other precautions taken the caisson was finally founded in its correct position. The masonry in the pier was then completed, and afterwards that in pier No. 4.

As stated, the building of the piers was in progress on each caission during the operation of sinking. Each day the levels and alignment of the caisson were taken, and from these instructions were given to the builders in their work, since they could not, of course, use the ordinary level and plumb rule. No alteration was required in the masonry after the caissons were founded beyond that already mentioned in the case of pier No. 4. A making-up course in the granite was provided for in the drawings, but it was not required, and the stones were sent to the site ready cut for their place.

The maximum air pressure recorded was 27 lb. per square inch over atmosphere. A few slight cases of "bends" occurred, but none was serious. The number of men employed in each working chamber varied from six to eight. The cranes used were: two 15-ton Morgan derrick cranes, two 10-ton Morgan derricks, and one 7-ton Forrest derrick, commanding the piers and erecting bay for caissons 2 and 3, and a 7-ton Coles traveller and a 5-ton Coles traveller in the storage yards. All were steam-driven. The concrete was mixed by two half-yard Victoria mixers and one half-yard Ransome mixer, two of which were steam-driven and one electrically driven. The Norwegian granite was shipped to Hull, and was there transferred to barges, which brought it alongside the discharging cranes at the bridge. Earle's red seal Portland cement was used throughout. This was brought by barge from Hull and stored in sheds until required. Trent ballast was used for concrete, and this was brought from the upper reaches by barges, from which it was skipped by the cranes direct to the mixers. The blue Staffordshire and Hepworth brindle bricks used were delivered by rail.

The masonry work of the several piers is shown by Figs. 19 to 26, on page 460, Fig. 22 showing also the caisson for the foundation of pier No. 2. As the sections, elevations and plans are fully dimensioned it is not necessary here to enter in details.

The construction of the east and west abutment proceeded concurrently with the building of the piers. The excavation of the foundation for the west abutment was begun in February, 1913, and the first pile was driven on March 4. Piling was

KEADBY BRIDGE; MILLING THE ROLLER LIFT SEGMENT.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

FIG. 40.

completed on April 17. The foundation contained 97 piles, 40 ft. by 14 in. by 14 in., driven into the gravel to well within the specified set of $\frac{3}{8}$ in. from a 1-ton hammer falling 10 ft. The piles were spaced from 3 ft. to 4 ft. 9 in. centre to centre in the direction across the centre line of the bridge, and from 3 ft. 9 in. to 4 ft. parallel to the same. The front row was driven to a batter of 1 in 16. The heads of piles were cut off 1 ft. 6 in. above the bottom of the foundation, so that they projected that amount into the concrete, which was filled in and brought up to the building level, the depth of concrete being 6 ft. The abutment is built in brickwork backed with concrete. The plinth course, quoins and cornices are of grey Norwegian granite. The girder bedstones were laid by September 30, 1913. The parapets and stringer bedstones were added at a later date. Figs. 27 to 29, on page 460, are sections of the west abutment.

Excavation for the east abutment was started on June 14, 1913, and piling was commenced on September 1, and was finished on October 23. The foundation contained 106 piles, and all were driven practically to a standstill. They were spaced 4 ft. 3 in. to 5 ft. apart, and the two front rows were inclined towards the river at a batter of 1 in 16. The concrete bed on the piles, 6 ft. thick, was reinforced by old rails. This abutment is similar to the west abutment. Main bedstones were finally laid on May 16, 1914.

The Scherzer rolling lift span is diagrammatically illustrated on the general elevation, plan and key elevations of uprights, Figs. 30 to 33, on page 461, while Fig. 34 is the camber diagram on the same scale. Full details of the roller end are shown on Plate XLV. In subsequent issues we shall publish corresponding drawings of the ballast box track girder and the outer half of the lifting span.

The dimensions of the rolling lift span may thus be tabulated :—

	Ft.	In.
Centres of bearings on piers Nos. 2 and 3...	160	6
Centres of cross girders	19	8½
Effective depth of main girders at fore end	18	0
Effective depth of main girders at rear or counterweight end ...	36	0
Width, centre to centre, of girders A and B across railway	29	3
Width, centre to centre, of girders B and C across highway	24	3
Camber of main girders	0	3½
Centres of bearings of track span ...	40	0
Depth of track span	10	0

There are three main trusses, each with its rolling segment, which roll on three track girders below. The trusses are rigidly connected together at the rear by the ballast box, which extends from side to side of the bridge. As shown in Fig. 30 the main girders are divided into eight bays, and the cross girders are suspended to the vertical posts below the bottom booms. The connection is stiffened longitudinally by the large gusset plates at the panel points, which are extended for that purpose (Figs. 32 and 33).

The two-page Plate, No. XLV, illustrates the rear end of the centre girder "B." Girders A and C are similar and differ only in detail.

The rolling segments only will be dealt with here, the remaining part of the structure of the roller lift span will be described later, when further drawings and illustrations will be reproduced. As shown on Plate XLV the rolling segment is double-webbed, each web being $\frac{7}{8}$ in. thick. The radius is 28 ft., and the depth at centre is 10 ft., the bottom or curved flange is built up of 8-in. by 8-in. by $1\frac{1}{16}$-in. angles and side flange plates. The top flange is made up of 8-in. by 6-in. by $\frac{15}{16}$-in. angles, side flange plate and one flange cover plate 3 ft. wide. For the purposes of shipment each segment was sent to the site in four pieces, there being a centre field joint dividing each half into two, and it was assembled and riveted in place.

The field rivets in the centre joint, diaphragm and connections to the ballast box at the one end, and the main truss at the other, are clearly shown on the Plate in the usual manner of a blacked-out circle. Those in the centre joint were $1\frac{1}{8}$ in. diameter, and the longest was 10 in. in length. They were snapped by a hydraulic machine. Those in the diaphragm and in the end connection were 1 in. diameter, and were closed by pneumatic machines. Careful arrangements were made by the contractors in their shops in Glasgow for the accurate machining of the segments to their true radius. This was done by a special milling machine. The segment built up complete, with the diaphragms, and centre joint bolted with fitted bolts, and the members of truss U^0—A_1 and U^0—M^A (Fig. 30) added, were laid on the table of the machine, which rotated about a fixed centre, as shown in Fig. 40, annexed. The segment was centred and then rotated in front of a vertical milling tool, on the table 3 ft. long, which milled the full width of the segment in the one operation. The curved flange of the segment was machined, the curved track plates fitted to the same, and the rolling surface of track plates machined to radius in successive operations. The curved plates are of high carbon rolled steel, breaking strength 35 tons to 40 tons per square inch, with 25 per cent. elongation in 2 in.

The position of the ballast box is shown in Fig. 35, Plate XLV, where it will be seen that a well-braced double web frame is provided throughout the cross-section in the plane of the rolling segments and the

top booms; but we defer our description until our next article, when we will publish detailed drawings of the ballast box.

The roller lift span may now be dealt with so far as the trusses and vertical posts are concerned, and so far as illustrated by the segmental end, illustrated in detail on the two-page Plate XLV. It will be seen from Fig. 30 on page 461, that the trusses are of the Warren type, with vertical subsidiary posts at each panel point. They are of 18 ft. effective depth at the nose end, and 36 ft. at the rear end, and are connected to the rolling segment and ballast box as shown on the two-page Plate XLV. The details of the girder construction as shown on this Plate are so complete and self-explanatory that little description is necessary.

The tops of the trusses are braced together by four portal trusses, placed at panel points U_0, U_1, U_3 and U_5. Details of one of these, that at U_1, are shown in Fig. 39, Plate XLV. This consists of a portal immediately above the clearance line of railway and highway, built up of 4-in. by 4-in. by $\frac{3}{8}$-in. and 6-in. by 4-in. by $\frac{3}{8}$-in. angles braced with flat bars. The top booms of the main truss are connected by box girders formed with angles and side plates, braced top and bottom with flat bars. Between these members extend diagonals built of 5-in. by 3½-in. by $\frac{3}{8}$-in. angles laced together with flats. About midway between the top struts and the portal, at the centre of rotation, is a hollow box girder extending between the trusses, which is built up of 2-ft. 6-in. by $\frac{3}{8}$-in. web plates and 4-in. by 4-in. by $\frac{3}{8}$-in. main angles. This girder forms part of the machinery platform, to be dealt with later when the machinery is described.

In supplement to the detail drawings we give on Plate XLIV, two photographic views both showing the old and the new bridges; in Fig. 41 the roller lift span is down, in Fig. 42 it is raised. The view on Plate XLVI, Fig. 43, gives a good idea of the proportions of the Scherzer span.

(To be continued.)

THE WORKING COSTS OF PRIME MOVERS.

On Monday last, the 29th ult., a meeting of the Institution of Mechanical Engineers was held at the Engineers' Club, Manchester, further to discuss Mr. Oswald Wans' paper on "A Comparison of the Working Costs of the Principal Prime Movers," read before the Institution in London on the 19th ult., and published in full in our last issue (*vide* page 451 *ante*). The president of the Institution, Mr. Michael Longridge, occupied the chair, and there was a large attendance.

The discussion was opened by Mr. F. Fielding, who stated that a firm in Manchester had that week received a letter from a customer, asking what value they would suggest should be placed on an internal-combustion engine which had been working for forty years. The spare parts were still in the same box in which they were sent out with the engine at the beginning; the firm had not had occasion to use one. The writer estimated that the present value of the engine, with the war advances, would be higher than the amount he paid for it. He was not contradicted. With regard to refuse fuel plants, the author pointed out that all traces of tar must be removed, as local authorities objected to it. Unfortunately, they objected to other things as well—ammonia and acetic acid. A considerable amount of the latter was found in most wood refuse, but could be easily removed from the water. There were hundreds of refuse fuel plants where the water was sent into the sewers after being treated; it was really quite a simple matter. Mr. Wans said in his paper that internal-combustion engines were more prone to minor mishaps than steam engines, and due allowance must be made. Mr. Hiller's paper, read before the Manchester Association of Engineers two or three years ago, dealt particularly with engines up to 50 h.p. or 60 h.p., and they did not need a better testimonial for internal-combustion engines than that. In his references to the refuse fuel plants, the author, apparently, had not considered other makers' plants besides those of the firm he represented. He (Mr. Fielding) was not going to mention names, but in Manchester one could buy several plants, and see others at work, which could be used not only for the various refuse fuels mentioned in the paper, but also for anthracite coal, coke or bituminous coal, such as would be used for a steam engine, without alteration. These plants could be run on refuse for half the week and on other fuels for the other half of the week, or they could be run with mixed fuels. The use of refuse plants was not confined exclusively to those people who had a good supply of the refuse fuel; a number of installations were working where there was nothing like the necessary quantity of refuse fuel, and yet they were working admirably. In reply to the chairman, Mr. Fielding said he could not give offhand the diameter of the cylinder of the engine which worked for forty years. It was a small town-gas engine.

Mr. Alfred Saxon said he spoke as a representative of the older branch of the prime movers referred to in the paper. He thought thanks were due to Mr. Wans for bringing the subject before the members in such an interesting manner. In dealing with a comparison of the working costs, the author placed before them a subject on which the merits of the various prime movers could be well discussed under a comprehensive title. He had rendered a service by pointing out to engineers and their representatives the advisability of not overstating the capabilities and performances of the plant they were offering to customers, and he approached the problem, so far as one could judge, in a fairly impartial manner. Coming to the paper, he (Mr. Saxon) agreed with the statement on the first page as to the commercial test being the ultimate criterion of the engine's worth. A reference was made in the paper to the capacity of the steam engine for dealing with overload in mills and manufactories. That was an important factor from the commercial standpoint. Later on in the paper, where the question of depreciation charges was dealt with, a rate of 8 per cent. was fixed. That should be ample. Perhaps he might be permitted to make the claim on behalf of the steam engine that it lent itself, better than any other prime mover dealt with in the paper, to being brought up to date by alterations, and in that way enabled to compete, as far as economy was concerned, with new steam plants. From his own experience he could furnish many examples, and fairly recent examples, of the truth of that statement. The result of the author's investigations showed that from the commercial standpoint there was room for all the principal prime movers. On behalf of each a claim for employment could be put forward on one ground or another. The greater freedom from breakdown of the steam engine—at any rate of large sizes, along with some small sizes which had now come into existence—and the less wear and tear were points much in its favour. Mr. Wans had felt obliged to confine his comparisons to units up to a working load of 500 brake horse-power; if the comparisons had been made with engines of higher powers the steam engine would certainly not have suffered by the change. From the commercial standpoint there was a great field for the remodelling of the steam engine and the manufacture of new steam plant in mills and factories for sizes ranging from 500 brake horse-power up to 3,000 brake horse-power.

Mr. T. Roland Wollaston said he intended to speak from rather a novel standpoint. He had been drawn into reading quite a number of papers on this subject, beginning with one before the Society of Chemical Industry, which had special reference to chemical works; before the Textile Institute, with regard to cotton and spinning machinery; before the Mill Managers' Association, with regard to bleaching; and before the Ceramic Society with regard to pottery works. He had one to come off in London early in the New Year with special reference to works management and power plant. He had, therefore, given some study to the subject, and he was very much interested in Mr. Wans' paper. He agreed with most of the general remarks on capital, cost, labour, maintenance and interest, lubrication, overload capacity and kid-glove tests. He was particularly struck with the last phrase. To what extent had Mr. Wans considered how electricity in the future was going to compete in powers up to 500 h.p.? The whole matter centred upon a point which he would raise later on—the load factor—but at this stage he might just say, though he must not develop it at all, that personally he saw no reason, except in regard to first cost, why electricity should not be obtainable all over the country, in practically every district, at ½*d.* per unit, and that would have a very important bearing on practically everything Mr. Wans had told them. He did not exactly agree with the author on one point, and he should be particularly glad to hear what Mr. Longridge had to say about it. That was the scrapping of the old power plant merely on the fuel cost basis. He had had many cases to analyse—and time and again he had been asked to look into such cases—where comparatively old engines in Lancashire mills had been consuming as much as, say, 2½ lb. of coal per horse-power, and he was asked to consider the advisability of putting in another engine which would consume, say, 1½ lb.—quite a substantial fuel-cost reduction. Upon going into the matter, taking the capital charges and everything else into account, it would be found to pan out in favour of keeping the old plant, perhaps with some modification. It was quite a simple matter of accountancy just to put the figures down and consider the relative values. Another point he wished to raise was that it seemed to him that everyone who wrote papers on subjects similar to the one they were discussing, appeared to think that it was fashionable to put everything in the form of a graph. In his opinion authors often went much too far in that respect, particularly when there were such variables as Mr. Wans was dealing with in his paper. When such things as capital costs, fuel cost, and particularly load factor, came in, it seemed to him that the graphs the author had shown them, Nos. 1, 5, 6 and 7, if taken at their face value on Mr. Wans' reputation, might lead many people into grave trouble either at the present time or after the war, because they were mostly based on pre-war prices. On the other hand, graphs 2, 3 and 4 were based on sounder and more permanent data, and they might be very useful. But all those involving capital costs and prices of fuel were, to put it mildly, dangerous. Mr. Wans had omitted what, to his mind, was the all-important point in deciding upon the type of power plant for almost any works. That was the load factor. It was just vaguely alluded to in the paper. So was the question of heating. In many factories in the Manchester district, such as bleaching and dye works, and paper mills, the amount of steam required for process work was two, three, four, five, and even six times as much as for power, and that must necessarily have a very large controlling influence in the choosing of the type of plant. Mr. Wans had alluded to the use of gas for heating purposes, and he (Mr. Wollaston) would just say incidentally that he believed there was a very large scope for the use of gas in place of steam in a great deal of process work. Returning to the question of the load factor, which seemed to him the most important point in the whole thing, he had been working out quite a number of examples. He had considered on what basis the load factor should be taken and just for the sake of comparison he had taken the ideal load as being, for example, a flour mill or an electro-chemical works running 7,000 hours per year, full time. He took that as 100 per cent. Then he had taken other examples at 40 per cent. load factor, and amongst those he included spinning and weaving mills and the like, where the working hours were in the neighbourhood of 2,800, which was just 40 per cent. of the 7,000. Then he dealt with another type working 10 hours a day, like a cotton mill, on an average load of nearly 50 per cent., and he had called that a 20 per cent. load factor. Just as an example he had taken a concrete case of a cotton-mill engine of which he had the fullest records in regard to capital cost, labour, stores and fuel, and it worked out in this way. Taking the same engine under exactly the same conditions, except in regard to load factor, he had allowed the necessary extra amount for labour and stores, and it appeared that on the 100 per cent. load factor the same engine would run at 0.23*d.* per brake horse-power; on the 40 per cent. load factor—that was a cotton mill which was actually running to-day—at 0.34*d.* per brake horse-power, and on the 20 per cent. load factor, such as would obtain in the average engineering shop, it was 0.51*d.* per brake horse-power. That showed the influence of load factor which, he believed, was absolutely the most important in deciding upon the power plant in works. Yet Mr. Wans had very nearly ignored it.

Mr. G. E. Windeler was sure that the manufacturers in the Manchester district would be pleased to have Mr. Wans' paper. That district was the home of the internal-combustion engine, and Mr. Wans would get, and probably expected, a very hearty discussion. He was entitled to thanks for the able and frank way in which he produced the information at his disposal and tried to give to each particular prime mover the position it deserved. For instance, Mr. Wans held that the Diesel engine was the highest grade of prime mover from the thermal point of view. Some of the particulars were open to criticism, especially that where it was stated that for the solid-injection oil engine "a higher price may be paid for fuel oil, namely, 3*l.* 16*s.* per ton as compared with 3*l.* for the Diesel engine," showing an advantage of 26 per cent. to the credit of the former. This was said to be due to the lower capital expenditure and other running charges. Now, taking the particulars, he found that he and the author were practically agreed that the Diesel and the solid-injection engine were substantially alike, but the Diesel was better with regard to water consumption. In regard to lubricating oil consumption the figure given in the paper for the Diesel engine was about 0.004 pint per brake horse-power. He had looked up a lot of particulars from power stations ranging from 100 h.p. to 750 h.p., and he found that the lubricating oil consumption worked out at an average of 0.003 pint per brake horse-power, so there was only a slight difference between them there. But the author's claim that there was this 26 per cent. advantage to his own engine, even though it used oil at 3*l.* 16*s.*, was not quite borne out. Taking the graph, Fig. 2, he found the fuel consumption of the solid-

injection engine—taking a 500-h.p. engine—was 8,050 British thermal units, or about 0.447 lb. per brake horse-power hour. The figure for the Diesel engine was 0.432 lb. per brake horse-power, or, in British thermal units, 7,780. If they took the consumption of oil during a period of 3,000 hours (which was a few hours working per day) they found that they used for the Diesel 289 tons, at 3*l.* a ton, a total cost of 767*l.* With the solid-injection engine there was a consumption of 299 tons, at 3*l.* 16*s.* per ton, which was approximately slightly over 1,000*l.*, leaving a difference of 233*l.* to the advantage of the Diesel engine. From the curves of the capital expenditure he saw that for, say, a 500-h.p. engine, the figures came out approximately in the ratio of 5,000*l.* for the Diesel and 4,000*l.* for the solid-injection type. On the assumption that 10 per cent. was the rate of interest upon the 1,000*l.*, he added 100*l.* to the fuel oil consumption. When that was deducted from the 233*l.* they still had an advantage of 133*l.* per 3,000 hours. Now there were very few Diesel engines in this country which only had to work 3,000 hours per annum. Very often they worked 20 hours a day, and in power stations longer than that. Of course, there were not many power stations fitted exclusively with the Diesel engine. He was rather inclined to agree with Mr. Wans' remarks about overload. Personally he always recommended the users of internal-combustion engines—whether Diesel or gas, or any other prime mover of that type—that they should, if possible, keep their load figures down to about 90 per cent., because there were prevailing conditions in a power-house, difficult to account for, which allowed an internal-combustion engine after a time to fall away from its power. It might be leakage through the exhaust valves, or the induction valves, or some other difficulty which they had not been able to analyse so thoroughly as to say that an engine could work at its full rating continuously and constantly. Of course, that might be said to be all the more reason why they should go to the big figures Mr. Wans indicated. Personally he should like buyers to take that view. Makers would certainly have a much easier time. All sorts of conditions, such as running engines at the full power or 10 per cent. overload, or even more than that, allowed the engine to run on a critical point, so that if they left the lubricating oil off a few seconds, or the water off for 10 minutes or a quarter of an hour (which was a frequent occurrence), the engine was so near the critical point that it was liable to damage and breakdown. There were more engines damaged by overloading than there were by underloading. Mr. Wans referred to the use of exhaust gases for the raising of steam. They had two cases where they raised steam at about 20 lb. pressure for use in laundries with exhaust-heated boilers. In other cases they had engines for working the machinery in flour mills and the exhaust heat was used for the conditioning of the wheat. He mentioned that because to his mind users did not absorb all the value of waste heat units which they should do. Of course, very often the cost of doing it was prohibitive. In regard to the solid-injection engine, personally he thonght it had its position and its future. The fact that it could approach the Diesel engine so closely in its consumption, as it appeared to do from the figures given by Mr. Wans, indicated that Ruston Proctors were on the right lines. He agreed that the oil engine had a very excellent position in the world of prime movers. One speaker had suggested that in this country electricity might take its place, but abroad there was a very large field for oil engines.

Mr. Burcham said the author, in placing the subject before them so nicely and systematically had rendered a great service and had added to the useful papers read before the Institution. It was noticeable that in the comparisons nothing was said about using the exhaust steam from steam engines. In many businesses the utilisation of the exhaust steam made the steam engine the best prime mover on the market for thermal efficiency; it converted into useful work perhaps 80 per cent. of the steam that was not used in the processes. In works where they could use large quantities of low-pressure steam of course the lubricant in the steam was sometimes objected to, the steam being a little oily, but that could be got over by the use of separators or by the use of steam turbines, which he classed as steam engines. Again, it must be remembered that the steam turbine, although not economical in small units taken by itself, became an equally economical unit if its exhaust could be utilised. If one could utilise all the heat it originated, surely it must be working efficiently from the thermal point of view. That was rather outside the scope of the paper, but it was not to be lost sight of in considering the type of engine to be adopted for a factory. He took it that the paper only dealt with cases in which small powers up to 500 were required, and where it was not practicable to take current from a big generating station such as Mr. Wollaston had in mind.

Mr. H. S. Raynor said he was afraid a great many people, by ignoring the financial side of the paper, might come to the conclusion that every prime mover mentioned was an all-purposes prime mover. That would be a very misleading conclusion to come to. In the early part of the paper the author mentioned the splitting up of the maximum power into several units. He might say that this applied to gas producers. One gas producer working into an engine direct was liable to a 30 per cent. fluctuation in the quality of the gas immediately before charging, and immediately after, so that it was an advantage to split up the units of producers, and let the products or the gases mix in the one common main. If that were done they got over that fluctuation. Later on, reference was made to the cost of building. They might take it that 10 per cent. of the cost of the plant was a good all-round figure for that purpose. Eight per cent. was given as the figure for stand-by losses. He had proved that figure dozens and dozens of times. 0.01*d.* was given as the cost of sundries. That should be more like 0.03*d.*

He noticed that the author had made mention of the use of suction gas for heating purposes. As one who had tried it many times he must say that he could not recommend the adoption of that system. In regard to leakage where there were a number of small leaks, one was very liable to get a very nasty explosive mixture in the holder. Reference was made to the use of town gas for gas engines. There, again, he could give the result of some experiences, and he suggested 25 h.p. to 30 h.p. as being the maximum to work with town gas. Turning again to the question of the suitability of the various prime movers for various works he might say that in some of the works he was connected with they got as much as 100 per cent. overload. That in itself would cut out a lot of prime movers. It rather pointed to the steam engine with a long stroke and plenty of driving power. The author made reference to kid-glove tests, or tests which were run on laboratory lines. He thought the small size of the internal-combustion engine lent itself to that sort of treatment admirably. There were some figures which he had been putting together with reference to very small engines such as were used in steam and petrol wagons. By careful observation of the running performances of those engines they found that 4.6*d.* per ton-mile was a reliable figure to be taken for steam wagons.

The chairman, Mr. Michael Longridge, in drawing the discussion to a close, said the outcome of the paper was very well summed up in the last words, "It is obvious, therefore, that the commercial superiority of a prime mover is not established by reference to its thermal efficiency; but by the local conditions regulating the price of fuel." In all prime movers the price of fuel was really the dominating factor. Taking internal-combustion engines he thought they would find generally that it was between 40 per cent. and 55 per cent. of the working costs; that was with fuel at 16*s.* to 60*s.* Mr. Wans had assumed that in the case of the steam engine the fuel cost ran up to from 60 per cent. to perhaps 70 per cent. of the total cost. The next big item was depreciation. In the internal-combustion engine that usually ran to somewhere about 30 per cent. of the total cost; in the case of the steam engine it was somewhere about 20 per cent. to 25 per cent. That was assuming they took the rate of depreciation at 10 per cent. Now 10 per cent. was sufficient to pay off capital in 15 years, and at the same time pay 5 per cent. interest upon all the debt that was not paid off, if the sum were paid by regular yearly payments, which was a thing manufacturers always wished to do. The formula was a very simple one to calculate, and he would put it in as a note to be printed in the report of the discussion.

Turning to the paper itself he was not able to criticise it very much, but he would like to say a word about capital charges. He did not think the curves for the Diesel engine were anywhere near correct. His experience had been as regarded the Diesel engines and other small engines starting at about 40 h.p., that the capital cost was somewhere between 16*l.* and 17*l.* per horse-power. Then the cost ran down very rapidly until they got to engines between 100 h.p. and 120 h.p., at 11*l.* or a little more per horse-power. After that it remained fairly constant until they got to very large engines; then it went up instead of going down. The reason was quite evident. In the Diesel, so far as his experience went, they could not indefinitely increase the size of the cylinder, but must increase power by adding cylinders, multiplying cylinders, and that ran up the cost of large engines above the point where it would be if they could construct them, like steam engines, with a couple of cylinders all the way through. He also found that the cost of steam engines for small units—40 h.p. or thereabouts—was higher than Mr. Wans' figures, running up to somewhere about 20*l.* per brake horse-power, and it ran down fairly rapidly until they got to about 300 h.p. or 400 h.p. Then it still ran down, but comparatively slowly, until they got to large powers which came out at 7*l.* or 8*l.* He thought the figures given on page 5 of the paper were fairly correct; they coincided with his experience. The figures for oil, wages and that kind of thing were the very figures which they wanted and could not get. They were given in most of the electrical papers for the electrical stations, and it would be a capital thing if the associations which regulated the various trades, or which would regulate them in the future, would insist upon manufacturers giving an analysis of the costs of their power. It could be done. It was done, he thought, by Act of Parliament at the electricity stations, and it certainly ought to be done at mills. In a fair number of cases figures had been given to him, but he could not say whether they were right or wrong as they were so variable. He did not think they could lay down any sort of mean figure as the author attempted to do in the paper. Coal and depreciation one could get at fairly evenly, and those were the two main points that settled the financial question, quite apart from the question of oil and labour. As regarded insurance the author had taken a certain percentage. Well that was quite out of the question altogether. Insurance did not go by percentage. They knew perfectly well that the first 100*l.* was called upon far more than the first 1,000*l.*, and the rate for 100*l.* of insurance upon an engine was a far higher percentage than the rate for 1,000*l.* It also depended upon the size of the engine, especially internal-combustion engines. Internal-combustion engines with cylinders under 15 in. diameter were perfectly safe things, but when they got to 20 in. and 21 in. they became risky and the rate of insurance went up considerably.

Mr. Wans, in replying, said Mr. Fielding had mentioned an internal-combustion engine which ran for forty years and seemed rather to suggest that he (Mr. Wans) was antagonistic to that type. On the contrary, he was pleased to hear that an internal-combustion engine had run so long; in fact, he thought it was a record in its way. The paper did not refer to one particular type of refuse gas producers, as Mr. Fielding seemed to suggest; it applied to all the refuse gas producers in a general sort of way. Mr. Fielding instanced the case of using different kinds of fuel, not only refuse but bituminous coal. Of course, that was quite possible, but the answer to the question whether it was a suitable scheme or not, would depend entirely on the price of that fuel; unless one knew the price at which it could be obtained it was quite impossible to say whether a producer working with mixed fuels was a suitable proposition or not. Ammonia and acetic acid were undoubtedly troublesome in the case of wood refuse gas producers. It depended largely where they were as to whether the question was raised or not. If water passed through a suction-gas plant once there was a proportion of acetic acid, but if the water was put away carefully it did not seem to raise much trouble. Then Mr. Fielding did not like the remarks made in the paper about the minor mishaps of the internal-combustion engine. He (Mr. Wans) was a great believer in the internal-combustion engine, but he must admit that though it had shown itself to be reliable, it did have small breakages which one did not find so often in the steam engine. Of course, it depended very largely upon the attendance; if it was properly attended to and sufficient care given to it the internal-combustion engine would give a good, reliable account of itself.

Mr. Saxon gave some interesting particulars. However the majority of his remarks referred to engines which were larger than those really stated in the paper. The possibilities of bringing engines up to date was no doubt a very important point, but he thought the same process could be applied in the case of the internal-combustion engine, always provided that a sufficient reservation was made for repairs. With regard to the question of the overload capacity there was no doubt that was an advantage in the steam engine, and in choosing an engine it must be taken into account. He agreed with Mr. Saxon that if the comparison were carried to a larger size of engine, over 500 h.p., it was quite possible the steam engine would give a better account of itself. Of course, one would have to include the steam turbine, and it seemed to him the comparison would have to be made between the steam turbine and the suction-gas plant used with a recovery plant. Therefore it was possible that the steam engine would not give such a good result as it promised to do when one considered the smaller sizes, and noted that with the steam engine the nearer it got to 500 h.p. the more likelihood there was of getting costs nearer to a suction-gas plant.

Mr. Wollaston had raised several points. One was with regard to electricity and how would it compete. He (Mr. Wans) was afraid he had no figures by him to give that information, and of course it was beyond the scope of the paper, as they were dealing with prime movers, and an electric motor could not be classed under that head. Mr. Wollaston did not like the idea of using

graphs to the extent given in the paper. He characterised it as a fashion. It might be a fashion, but he (Mr. Wans) was inclined to think it was a very good fashion in a paper of that description. Many points would be missed if one gave a whole heap of figures. Figures were most annoying things where a line showed a great deal, and the results could be seen very readily. Mr. Wollaston also touched upon the question of heating and the amount of steam required for that purpose. Of course, if a large amount of steam was required that certainly introduced another factor, because the exhaust-heated boiler when working in conjunction with an internal-combustion engine could not give a very large amount of steam. In some cases the amount it could give was useful, but in a cotton mill and other instances of that description the internal-combustion engine, he was afraid, would not be able to supply all the steam that was required.

He should like very much to consider all the figures Mr. Windeler gave; but there were so many that he had not been able to grasp them all. He understood the point was that Mr. Windeler could not account for the 26 per cent. higher price of fuel in the case of the solid-injection engine, and picked out several instances in which the Diesel engine gave better results than the solid-injection engine. He agreed. So far as he could remember he thought he should agree with the figures, too, but he should like to see them again. There was one point in which the Diesel engine was very much disqualified. That was in the capital expenditure. He had given what he thought were fairish figures, but, as the president had told them, so far as his experience was concerned, those figures were not high enough. So, in point of fact, that would put the Diesel engine in an even worse position than was stated in the paper. Mr. Windeler said he would be very pleased if customers would adopt the overload suggested in the paper. He (Mr. Wans) thought all internal-combustion engineers would be in the same position, but at the same time he was rather inclined to think the engineers were themselves partly responsible because very often they overrated their engines, and that was unquestionably the cause of a tremendous lot of trouble. His experience was that an ordinary internal-combustion engine must have an ample power margin. If that was given the results were extremely satisfactory and the engine would give regular and reliable running. With regard to exhaust-heated boilers as applied to Diesel engines, he should be very pleased if Mr. Windeler would give some figures as to what the evaporation would be. Mr. Windeler also made some references to the solid-injection engine, which it was very kind of him to make in view of the fact that he was an advocate of the Diesel engine.

Mr. Burcham had referred to exhaust steam heating. Of course, that was worthy of consideration, but he did not think it would come into question with the power units dealt with in the paper; that was to say under 500 h.p. In fact, he understood Mr. Burcham took that view. Mr. Rayner raised the question of all-purposes prime movers, and suggested that it might be inferred from the paper. Certainly that was not the idea. A prime mover should only be chosen as the result of the conditions obtaining; he took it that there was no such thing as an engine that would do all kinds of work. Steam engines were suitable for the majority of work, but others were particularly adaptable for other kinds of work. For instance, if they took pumping. In a great many cases pumping probably required a steam engine, but occasionally an internal-combustion engine was used. There were many other points which Mr. Rayner raised. In some cases he agreed, and in some others he did not think that the figures quoted were high enough. Owing to the time he must ask to be allowed to reply in writing to the other points that had been raised. The president had added some useful remarks, and on these he had not at the moment any criticism to offer.

A vote of thanks to Mr. Wans was moved by Mr. Robert Matthews and carried unanimously. A vote of thanks to the president concluded the meeting.

THE DANISH CEMENT INDUSTRY.—The Danish cement factories are still unable to commence working, from want of fuel. Hopes in regard to probable arrivals of English coal have not materialised, and the experiments with lignite have so far yielded no satisfactory results. In the meantime the temporary Cement Board manages the distribution of the very scanty stocks.

THE SWEDISH BALL BEARINGS INDUSTRY.—One can now speak of a Swedish ball bearings industry. There were already three large companies, financially strong and flourishing, and now a fourth, the Baltic Ball Bearings Company, has been floated under the most auspicious circumstances for the exploitation of new valuable inventions within this field. The location of the new concern has not yet been decided upon, but the minimum capital of £270,000 has already been fully subscribed.

DRAUGHTSMEN AND FOREMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—It was with interest and pleasure that I read the letters concerning the Draughtsman's Association in your issues of October 19 and 26. Being a member of the Manchester branch of the Association of Engineering and Shipbuilding Draughtsmen, I am anxious for its success, and extremely thankful to find that the haughty contempt of the draughtsman against combination is fast disappearing. The war has taught us that only by strong combined effort can progress be made, and I trust that each member of the rank and file will do his part in moulding and shaping the future of the association. Our profession is responsible for producing efficient and cheap design, and this high standard can only be maintained by relieving us as much as possible from the domestic worries with which we are all faced.

The annual meetings are close at hand, and we should see to it that we elect representatives to our various branch councils who possess human sympathy and breadth of vision and a little less idle rhetoric. If my information is correct we are not a registered society, and I think the time is opportune for us definitely to ally ourselves on the side of labour and become registered as a trade union. There are those within our midst who argue that we should register as an educational society and dwell only in the realm of technical matters, patiently waiting for the silver lining to descend from the black cloud. They point to the doctors' and the lawyers' societies as the ideal to be attained. Now, I maintain that there is no parallel case. The doctors and the lawyers are their own employers, while draughtsmen are employees, faced with similar conditions of employment as the men in the shops.

I take pride in the fact that one of the most important features of our association's work is the desire to educate our members by lectures and discussions, given from the practical point of view; this can only lead to efficiency, accompanied by a brighter outlook upon engineering generally and a greater increase of mutual knowledge; but one cannot lose sight of the fact that when in Rome one must do as Rome does, and it requires very little thought to realise that only the trade unions receive any kind of consideration from the Employers' Federation and Government departments. We need not adopt all the methods of the orthodox unions, but it is extremely essential that we should build up a strong organisation, financially and numerically, that will be able to repel any unfair encroachment upon our profession.

I am, yours sincerely,

SENIOR DRAUGHTSMAN.

Manchester, October 29, 1917.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the various articles dealing with the earnings of draughtsmen, and have also noted that the skilled mechanics are to have 12½ per cent. increase to their wages, but cannot see anywhere that the draughtsman is to have more remuneration for his most important service and brain fag. It is about time that the Ministry of Munitions gave this body of practical and technical men some consideration, as without the draughtsman the works and the skilled mechanics would be of very little use, as it is the draughtsman who supplies the works with his technical knowledge, which he has attained after years of study in this particular branch of engineering industry. But, as one of the articles says, the work of the drawing-office staff is kept a secret and never seen; and, moreover, at the present time these secrets must not be divulged, or they would have other authorities to face.

The drawing-office staff in most firms is not getting a pre-war wage, in accordance with the present taxation and cost of living, and it is time that the Ministry of Munitions gave some consideration to the men who supply the works with its technical requirements and make their salary according to the standing of their profession and position, which is one of the highest in the engineering trade. As stated above, the works could not go on without the drawing-office staff, as it is this staff which supplies the mechanic with the knowledge he knows nothing about. I may say that there are many thousands of mechanics that do not know what the machine or parts of machines are for, or where they are to go, and could not even fit them together except for the blue print that comes from the drawing office.

For an example between the draughtsman and mechanics: the draughtsman's work is to design the machine, working out the stresses and strains, &c., which the mechanics know nothing about, and only work to the drawing-office instructions; so it is seen that the drawing-office staff is a very important body of men, who have up to the present time been badly treated. But it is to be hoped that the Ministry of Munitions, which is one of the principal departments of State, will give a few moments to consider the just cause of grievance which the draughtsmen have; and I am sure that after consideration the Minister of Munitions cannot help but see that draughtsmen have not been properly treated, and will thus at once have the matter put in order by giving them a proper salary according to their position and profession in the engineering industry.

I am, Sir, yours respectfully,

Ashford. MECHANICAL DRAUGHTSMAN.

TO THE EDITOR OF ENGINEERING.

SIR,—I have been interested in the correspondence *re* "Draughtsmen," appearing in your columns recently. But there are numerous other grievances peculiar to draughtsmen. Take one of the more recent ones, which is not mentioned in any of the previous letters.

It is stated officially that leaving certificates are abolished as from October 16, 1917, &c., &c., yet if we turn to your advertising columns under "Situations Vacant" we find that draughtsmen are wanted, but those who are engaged on war work, or who live more than 10 miles away, or have some other disqualification, cannot be engaged. I see from an Editor's Note added to a letter from Mr. Walker appearing in your issue of October 19 that you propose to deal with the questions raised in an early issue of your paper. When doing so, will you explain what good purpose can accrue to draughtsmen by abolishing leaving certificates if the Government, under the Munitions of War Acts, make it just as difficult as before for draughtsmen to get other work? Personally, I would rather have the leaving certificate than the present hypocritical way of dealing with the matter. Don't you think that the above appendages to your advertisements ought to be dropped as well as the leaving certificates?

Again, in the matter of the recent award of a 12½ per cent. bonus to skilled workmen in the engineering trade who are not receiving piece-work rates, in the first notice issued to the papers, I read that this award did not apply to skilled men "on the staff," but only to those who were in receipt of time rates, or something to that effect. Later I see another statement that engineering draughtsmen and other skilled men are to receive this bonus if they are in receipt of time rates; but I really cannot tell whether draughtsmen are to receive this bonus or not even now, if they are considered as "on the staff;" though why a skilled workman in receipt of time rates should get this bonus, while another skilled man who is receiving upstanding wages should not get this bonus, I do not know.* The official notice mentioned above was issued under the heading of "The Skilled Man's Grievance." Surely draughtsmen are skilled, and have many real live grievances.

A pattern maker gave it as his opinion that the reason why they could get so little satisfaction out of the Ministry of Munitions was possibly due to the officials in charge having the mistaken notion that a pattern maker was one who made paper patterns for ladies' dresses, &c. Perhaps the difficulty with us is due to the fact that, being draughtsmen, of course we are makers of draughts, suitable for games. Unless some stupidity of this sort is at the root of the matter, how can we account for the treatment meted out to draughtsmen?

I think the time is fast approaching when we shall have to use the same methods as the trade unions have used, or threatened to use. A lead from the Association of Engineering and Shipbuilding Draughtsmen in this direction would be eagerly followed by the majority of draughtsmen. This being a time of war, it seems that the only methods which stand the slightest chance of any success must be fighting methods.

October 30, 1917. "DRAUGHTSMAN" (Midlands).

[* The official announcement will be found on page 469.—ED. E.]

"STANDARD FACTORY ORGANISATION."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with particular interest the article which appeared in your issue of October 12 under the above heading. Factory accounting and commercial organisation have been so frequently ventilated by writers who do little more than confirm the old adage, "Fools rush in where angels fear to tread," that it is quite refreshing to read anything by one who really knows his subject.

In a paper recently read before an engineering institution the author remarked: "The perfect cost system should be capable of showing at a glance the cost of work as it proceeds, but, unfortunately, the system has yet to be devised." Another writer, a few weeks ago, in a contemporary of yours, stated: "Whilst not claiming that charges based on labour are perfect, they are certainly more accurate than those reached by any other known method."

It is evident from the above alone that both these writers have only superficial knowledge of factory organisations. The article in ENGINEERING on "Standard Factory Organisation" very effectively disposes of both statements. My object in drawing attention to the foregoing is, of course, to protest against inaccurate assumption, which may be misleading to those who rely upon information provided by technical journals, &c. It is very depressing to listen to papers and the discussion thereon, or to read articles the whole of which is simply a résumé of the very limited experience of the speakers or writers. It is also decidedly painful when one has to tender against others who do not know the true basis of production cost.

I am sure "Standard Factory Organisation" has appealed to many others as it has to me, and that through it more purpose will be put into the efforts of inquiring firms to arrive at agreement in costing and estimating methods.

The remarks of Sir Robert Hadfield on this matter which you quote are exceedingly pertinent. Might I suggest that the writer of your article would have increased its value by giving a few illustrations and figures to emphasise a number of his points?

Yours faithfully,

"Q. E. D."

Walthamstow, October 25, 1917.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has issued a copy of a new list (No. 38) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

PLATE-BENDING PRESS.

We annex an illustration showing a type of hydraulic press for bending plates, of which a number have been made by Messrs. Hollings and Guest, Limited, of Birmingham. The particular press shown by our engraving is one constructed for dealing with plates 6 ft. wide and up to $\frac{1}{2}$ in. thick; but many presses of the same type have been made for dealing with plates up to 12 ft. wide, the design of the framing, in addition to being economical, lending itself readily to modification to suit different widths of plates. In the press illustrated the ram has a diameter of 14 in., as the press was constructed to work in connection with a low-pressure main.

The press is fitted with a quick-acting withdraw ram at the bottom. In the illustration the bending tools are not shown, these of course depending upon the class of work to be done. The press can be placed in the ground at any convenient height, and only requires a small pit for the withdraw cylinder, no heavy foundation being necessary.

WAR PROFITS IN GERMAN INDUSTRIES.

The German Rock Oil (Erdöl) Company (there is also a German Petroleum Company) has a surplus for last financial year of 3,003,690 marks, against 609,315 marks for the previous year, a dividend of 25 per cent. being declared, against 6 per cent. for the preceding year. The increased profits for last year are not exactly due to an increased production, but to the fact that some old, less favourable contracts (principally with the Vacuum Oil Company) have terminated, whereby it has been possible to secure better prices. Provisions have also been made for the reconstruction period.

The Lindenberg Steel Works, which pays 25 per cent. and a bonus of 100 marks per share, besides providing gratis a new share to the holders of every three old shares, states that this result was not only justified by the large profits earned but greatly by the new, important technical improvements and the material savings which they entailed. The turnover-capacity of the works had been much enhanced, since many contracts have been completed during the first three months of the current year, and during the last six months of the previous year.

The Georg-Marie Iron Works and Mining Company last year earned a working surplus of 16,573,522 marks, against 9,965,663 marks for the previous year; expenses and writings-off amounted to over 7,000,000 marks, or about double the amount for the preceding year, and special reserves to over 3,000,000 marks, against 1,000,000 marks last year. The dividend has been fixed at 10 per cent., against 5 per cent. last year on the ordinary and 7 per cent. on the preference shares. A sum of 1,000,000 marks has been reserved for social welfare purposes, and the balance of some profit reserve from the transformation of the preference shares will be applied to the building of workmen's dwellings, in which respect the company has been a little remiss.

The Kalk Machine Factory pays a dividend of 20 per cent. for last year, against 16 per cent. for the preceding year and 10 per cent. for 1914–15. Employment has been still greater during last year than in 1915–16, and the turnover has increased in consequence. The company has orders in hand for a long time to come, and the present year promises to be as satisfactory as the last.

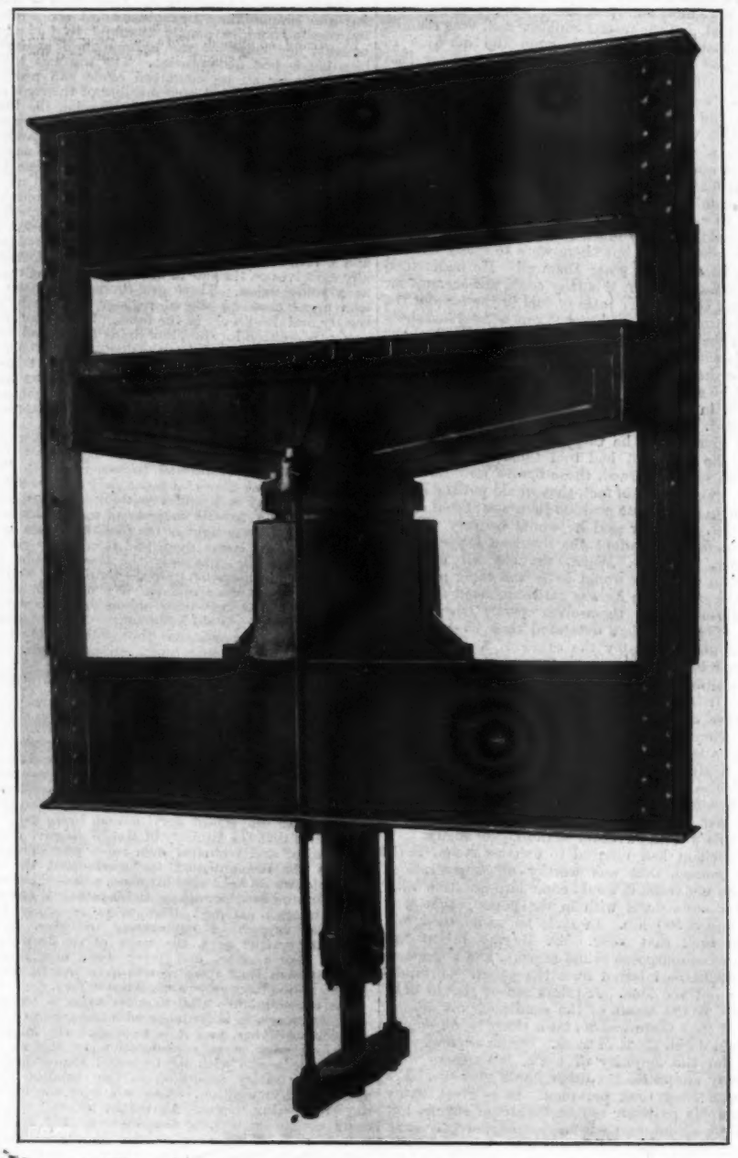
The Carl Berg Metal Goods Company, Eveking, in Westphalia, earned during last year gross profits amounting to 6,608,814 marks, against 3,135,894 marks in 1915–16, the reserve for war taxation having already been provided for. The turnover has materially increased, and the increase of the capital from 3,000,000 marks to 5,000,000 marks has proved very advantageous. General expenses have considerably increased, the net profits coming out at 1,832,932 marks, some 500,000 marks more than during the previous year, writings-off having been duly provided for, and the same dividend, 15 per cent., as last year, but on the increased capital, was declared.

The Trier Rolling Mill last year earned net profits of 931,919 marks, against 293,909 marks for the previous year, the dividend being fixed at 15 per cent., against 11 per cent. for 1915–16. The report states that the large number of orders compel the company to proceed, as quickly as possible, with the extensions planned before the war, which were based on experiments and preparatory work extending over several years. The capital has also been increased from 2,000,000 marks to 3,500,000 marks.

The Mannesmann Tube Works, whose gross profit for 1916–17 (52,200,000 marks) is three times that of the last peace years, state in their report, that for fear of coercion they disposed of their Italian works below their value, and that their English works have been compulsorily disposed of. Not knowing how much would accrue to the mother company from the transactions after the war, the amount has been written-off. Although heavy the writings-off, 12,800,000 marks, and reserved sum, 8,900,000 marks, cannot cover the incalculable loss which the company's selling organisations all over the world have suffered from the war, a fact which should be borne in mind in the face of the present large profits arising from the war. After the conclusion of peace, much labour and heavy outlay will be needed to reconstruct the former international connections, and a sum of 4,000,000 marks has therefore been reserved for reconstruction. The fact that, generally, expenditure has increased comparatively little, is due to the company's excellent organisation. The credit at the banks has been doubled, and now amounts to 50,300,000 marks.

HYDRAULIC PRESS FOR BENDING PLATES.

CONSTRUCTED BY MESSRS. HOLLINGS AND GUEST, LIMITED, ENGINEERS, BIRMINGHAM.



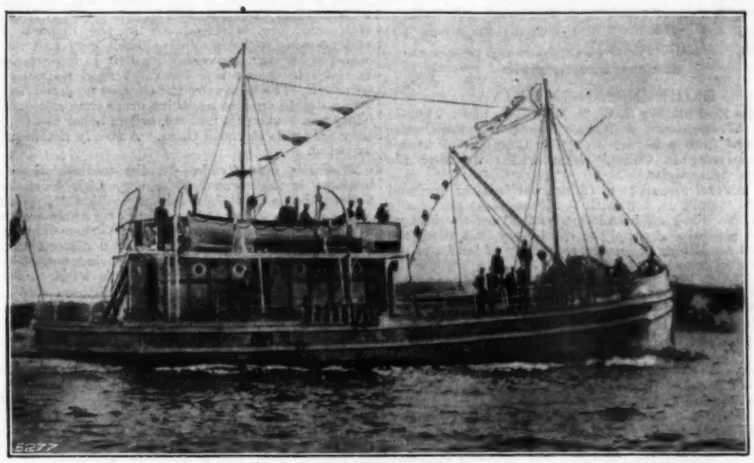
Cost of Electric Pig-Iron in Sweden.—According to the *Jern Kontorets Annaler*, the following is the estimated cost of 1 ton of pig-iron produced by electricity in Sweden:—

	At Gellivara. £	s.	d.	At Lulea. £	s.	d.
1.6 tons of ore (50 per cent. ore and 50 per cent. briquettes) ...	0	18	3	1	1	7
Limestone	0	0	8	0	0	5
0.4 ton of charcoal ...	1	0	10	0	18	1
0.272 kw.-year electric current	0	14	5	1	0	4
Electrodes	0	1	10	0	1	8
Repairs and maintenance	0	3	8	0	3	4
Wages	0	6	6	0	5	5
Management and sundries	0	2	3	0	1	11
Royalty	0	1	5	0	1	5
Sinking fund	0	3	7	0	3	3
Rent	0	5	9	0	5	5
Carriage to Lulea ...	0	4	10		—	
Total	4	4	0	4	2	10

Lantern Slides for Lectures.—Messrs. E. Bennis and Co., Limited, 28, Victoria-street, S.W.1, inform us that they have a large number of lantern slides dealing with the development and present practice in connection with automatic stokers, coal elevators and conveyors, &c., which they will be pleased to loan to any responsible inquirer for lecture purposes. A set of slides on the subject of ash removal is in course of preparation and will be ready shortly. A list of slides and particulars of their subject-matter can be obtained on request. Applications for slides should be made as far in advance of the lecture date as possible.

Swedish Shipbuilding and Harbour Works.—On September 14 the steamer Viken, 3,100 tons deadweight, built for the Swedish Transatlantic Company, was launched from the Lindholmen yard, and on the 29th of the same month it was delivered to the owners. The trial trip was to be undertaken as soon as the steamer had taken cargo on board. Important harbour works are about to be undertaken in Stockholm, after deliberations extending over several years. They comprise the construction of the new Hammarby channel which is to connect the Mälaren with the Saltsjön, *i.e.*, the waters east and west of Stockholm, and the deep water harbour at Lindaräugen which is to form part of the new free harbour project. The municipality of Stockholm is contemplating a 20,000,000 kronor loan to cover the cost of the works in question (18 kr. = 1*l.*).

THE FERRO-CONCRETE VESSEL "NAMSENFJORDS."



For quite a long period tug-owners have been anxious to employ tugs fitted with oil engines in preference to steam engines, on account of the reduced cost of running, but so far there has been a slight drawback, in view of the reduced weight of machinery. With a cargo vessel this reduced weight is naturally of considerable benefit to owners, but with a tug weight is essential. A reinforced concrete tug fitted with an oil engine would have a somewhat similar displacement to a steel vessel fitted with steam machinery, therefore it is quite anticipated, providing the experimental vessels now under construction in this country prove a success, that tug-owners will consider the oil-engine concrete tug proposition on really serious lines.

In our issue of October 5, on page 365, we mentioned the launch from the Moss yard in Norway, of the motor-boat Namsenfjords, and now, by the courtesy of Messrs. James Pollock, Son and Co., of 3, Lloyd's-avenue, E.C., we give a view of the vessel. She has a length of 84 ft., with a width of 20 ft. and a draught of 11 ft. 6 in., on which she carries 200 tons of cargo. Her 80 brake horse-power Bolinder engine gives her a speed of 7½ knots. It was found on her trial trip that vibration was practically non-existent, and that she behaved well in a seaway. We have already discussed the advantages and disadvantages of ferro-concrete construction on several occasions. Already quite a number of firms are engaging in their construction, and their immediate future will be watched with great interest.

THE EDUCATION OF APPRENTICES.

On Thursday, October 18, a representative deputation from the North-East Coast Institution of Engineers and Shipbuilders waited upon the President of the Board of Education (the Right Hon. H. A. L. Fisher, M.P.) to submit for his consideration certain matters relating to the education of apprentices to the engineering and shipbuilding industries.

Mr. Fisher was accompanied by the Right Hon. J. Herbert Lewis, M.P., Parliamentary Secretary to the Board of Education; Sir L. Amherst Selby-Bigge, K.C.B., Permanent Secretary to the Board of Education; Mr. F. Pullinger, C.B., Chief Inspector of Technical Institutes and Evening Schools, Board of Education; Mr. E. K. Chambers, C.B., Principal Assistant Secretary, Technological Branch, Board of Education; and Mr. F. H. Oates and Mr. N. D. Bosworth-Smith, Private Secretaries to the President.

The deputation consisted of His Grace the Duke of Northumberland, K.G.; Mr. Herbert B. Rowell, M.Inst.C.E., President of the Institution; Major-General Sir Percy Girouard, K.C.M.G., D.S.O., chairman of the North-East Coast Engineering Trades Employers' Association; Colonel Sir Johnstone Wallace, K.B.E., vice-chairman of the Newcastle-upon-Tyne Education Committee; Mr. W. H. Dugdale, M.Inst.C.E., vice-president of the Shipbuilding Employers' Federation; Mr. M. C. James, chairman of the North-East Coast Ship-repairers' Association; Mr. George Jones, chairman of the Tees and Hartlepool Shipbuilders' Association; Principal V. A. Mundella, M.A., B.Sc., of the Technical College, Sunderland; Mr. Edwin L. Orde; Mr. George Renwick; Mr. Percival Sharp, B.Sc., Director of Education, Newcastle; Professor R. L. Weighton, M.A., D.Sc., Armstrong College; Mr. Tom Westgarth; Colonel R. Saxton White, V.D., M.Inst.C.E., chairman of the Tyne Shipbuilders' Association; and Mr. E. W. Fraser Smith, secretary of the North-East Coast Institution.

The Duke of Northumberland, introducing the deputation, informed the president that the North-East Coast produced over one-half of the kingdom's warship and mercantile tonnage and over one-third of the kingdom's total output of marine engines. The marine engineering and shipbuilding industries employed about 14,000 apprentices.

Mr. Herbert Rowell stated that the deputation desired to emphasise certain features of the Report on the Education of Apprentices which was issued recently by the North-East Coast Institution, and to submit several recommendations. The Education Bill which Mr. Fisher introduced to the House of Commons in August paved the way to a serious consideration of that important side of education and encouraged them to believe that their representations would be sympathetically listened to. The report sprang from a demand for an efficient system of technical education for their apprentices. It rejected developed elementary day schools and laid it down that the most suitable type of school for the prospective engineer was the junior day technical school. It requested that the latter should be regarded as a distinct type of higher school, in no sense inferior to a secondary school, which boys could enter direct from the elementary schools at 12 to 13 years of age for a full-time three years' course of directed preparatory education, before beginning their apprenticeship. It demanded that adequate provision of these schools should be made in the North-East Coast area. In the establishment, management and general supervision of these schools, it was hoped that the North-East Coast Institution (representing the employers' associations already enumerated) would act on a body, which should also be representative of employees, in consultation with the local education authorities. The Institution endorsed in the strongest possible terms the regulations of the Board of Education which required that a reasonable proportion of the members of the teaching staffs of such schools must have had practical trade experience of the occupations for which the schools furnished educational preparation. The Institution regarded it as equally important that the inspection staff of the Board of Education charged with the supervision of the work of these and allied schools should be technical men with experience in the industries. It was also urged that the advisory body just referred to should have full opportunity of consultation with the inspection staff and with the chief administrative official immediately responsible to the Secretary of the Board of Education. Mr. Rowell referred in detail to the Board's regulations for junior day technical schools and expressed the view that the declaration in the regulations that they were "not intended to promote the establishment of courses planned to furnish a preparation for the professions, the universities or higher full-time technical work" was open to grave exception, as viewing the work of such a school as lying within a *cul-de-sac*. The Institution's scheme regarded such schools as places where the preparatory education of a prospective engineer or shipbuilder should be well and truly laid and where provision was made for the continuance of that education in a senior technical school during the apprenticeship of the brightest pupils and continuing to the university. The point was, surely, one of spirit rather than of administration, for he could not imagine that the Board would deliberately arrest a sequential scheme of development such as that set out in the Institution's report. Nevertheless, the deputation thought it desirable to have a definite assurance on the point. They realised that, if the scheme of education indicated in the report came into force, the engineering and shipbuilding companies concerned would be called upon to bear not only the cost of providing their apprentices with the facilities necessary under the scheme but, also, a heavy share of the increase of taxes thereby entailed. They believed, however, that the extra expense involved would be returned to the community in a far higher degree, on the one hand by the greater skill of the workman and, on the other, in the broader mental outlook, balance and initiative of the individual. They would like to see such a scheme adopted nationally, but if that could not be done at first, they were prepared to recommend its adoption on the North-East Coast. The old family relations of master and apprentice, which raised craftmanship to a dominating height, were gone, but they could at least see that the neglect and exploitation of apprentice labour that had largely prevailed for half a century died also. The close personal instruction of the old days of the guilds could, at any rate, be replaced by a high standard of collective training, with—where the size of the works allowed—a suitable person to act as mentor and guide to the apprentices. They earnestly hoped that their work in that matter would not dissipate, but that, through the machinery Mr. Fisher would set up, it might become a source of energy and inspiration to the rising as well as to future generations.

Sir Percy Girouard said that, on behalf of the North-East Coast Engineering Trades Employers' Association, he endorsed in every way, generally speaking, the proposals of the Institution. He realised that the scheme would mean a great addition to the number of apprentices in some departments, but he thought that most companies were prepared to meet that expense, as the Institution's proposals, if carried through, would give them much more highly-educated apprentices, who would have much greater chances of going into the higher spheres in engineering, in management and, even, administration than in the past.

Colonel R. Saxton White endorsed the report and described the progress of the apprentices' school in connection with Messrs. Armstrong, Whitworth's Walker shipyard. That school started three years ago with 40 students and now had 74. The training was voluntary on the part of the boys.

Mr. W. H. Dugdale, Mr. George Jones and Mr. M. C. James spoke in endorsement of the Institution's scheme.

Sir Johnstone Wallace, on behalf of the Newcastle Education Committee, said that authority heartily and enthusiastically supported the scheme.

Principal Mundella and Mr. Percival Sharp adduced arguments in support of the aims of the deputation.

Replying, the President of the Board of Education said he regarded that deputation as a very encouraging sign of the interest large employers of labour were taking in the promotion of technical education in this country. He was sorry to say that he found, all over the country, a very considerable amount of suspicion among working-people so far as technical education was concerned. However, it was part of the duty of that Board, in co-operation with the industries and with local education authorities, to dispel that suspicion. He would give very careful consideration to the points raised by the deputation as to the regulations governing the junior day technical schools. The point with respect to finance could not be settled without consultation with the Treasury, and he should have to review the whole circumstances of the case before arriving at a decision.

Hitherto, a certain number of forward and intelligent employers had provided continuation schools for their workmen, and he had never heard an instance in which an employer who had taken that step had regretted it. Employers who did take that step were, of course, exposed to the competition of other employers who had not taken the step, but he believed that, when the obligation of providing day continuation classes for pupils who had left school before the age of 16 became general—as was proposed by the new Education Bill—and was imposed upon the whole country, there would be many more employers ready to take advantage of the facilities given them under the Bill and to provide classes in connection with their work. He took it that he was right in supposing that the deputation was very clearly of opinion that it was desirable, in the interests of the industry, that apprentices should have, at least, a full-time education in a junior day technical school or elsewhere in a secondary school up to the age of 16.

Mr. Rowell interposed that that age was mentioned as being within the time and the period of apprenticeship. The education should be up to the time of apprenticeship.

Mr. Fisher remarked that that was, of course, a most important step forward in English education. He considered that it was the most important step that had been taken by anybody, because, if it was generally known that it was the considered opinion of a great industry, such as the engineering industry, that boys should have a full-time education, if possible up to the age of 16, it would create an immense improvement in the education of this country, react upon a great number of other industries and conspire, in a very remarkable way, with one of the purposes of the Education Board, which was to put a special premium upon full-time education up to the age of 16, any boy receiving such a full-time education being exempt from any further part-time education. He was particularly glad, therefore, to have received that assurance from the deputation.

The Duke of Northumberland thanked Mr. Fisher for having received the deputation and the interview ended.

The Bear Island Coal Deposits.—An expert who has returned from Bear Island and who has worked both there and at Spitzbergen states that the coal worked at the former place is quite as good as the Spitzbergen coal and is more easily worked. The coal in both places lies in horizontal layers, and deep working is not necessary, but at Bear Island work can proceed throughout the winter, and with 24 men, divided into two shifts, an output of 400 tons a week can easily be reached. The production can, of course, be much increased; 2,000 tons have been broken this summer. The coalfields in question appear to be very rich.

ELECTRIC HEAT STORAGE IN BOILERS.

We referred briefly on page 496 of our last volume to experiments conducted by the Swiss Association of Boiler Proprietors on an electrically-heated steam boiler. We illustrate in Figs. 1 to 5 on page 470 a type of electric steam generator which for some years past has been in use in large numbers in many Italian works. The inventor and patentee of the arrangement is Engineer Revel, Colonel in the Italian Army; and the apparatus is built by Messrs. Luigi Boselli and Co., Milan.

The principal characteristic feature of the generator is that for the transformation of electric energy into heat, and thereafter the steam, use is made of the ohmic resistance of the water which has to be evaporated. In the Swiss apparatus referred to above only a direct current is employed, which greatly limits its application, since few works dispose of this class of current in large quantities. The Revel apparatus, on the other hand, can be inserted in any alternating-current circuit of from 200 volts to 3,600 volts, and these are the form of current and pressures which are usually supplied for industrial purposes. In the Revel system, moreover, the production of steam is regulated automatically and continuously as required; the apparatus is entirely automatic in its action and demands no attention. Lack of feed water would only result in a decrease or a stoppage in the production of steam until the feed water difficulty was overcome. A 97 per cent. to 98 per cent. efficiency is claimed for the Revel type of machine, since the whole of the heat generated by the electric energy is absorbed by the water, the only loss being that caused by radiation from the body of the apparatus; this compares favourably with the 90.5 per cent. efficiency stated to be that of the Swiss machine.

The Revel generators are constructed to work at any pressure up to 14 atmospheres, and can be connected up at any time with the steam pipes from the ordinary steam boilers; owing to the rapidity of their action they take up any excess of hydro-electric energy which may be available even for a short time. They may, in fact, be considered as serviceable appliances for turning to account any superfluous hydro-electric power available, and as such they were utilised in numerous installations in Italy before the war, when the price of coal did not exceed 32*s.* per ton. At the present time they are also found to be practical and economical, even in cases where hydro-electrical power has to be paid for at the rates now ruling.

Figs. 1 to 4, page 470, illustrate an apparatus taking current at a pressure of 500 volts, in which the references are the following: A, electrode and steam space; B, cold water space; C, cover (steam dome), through which run three brass rods *a* electrically insulated from the cover; D, steel electrodes rigidly fixed to the rods *a*; E, steam pipe; F, steam pipe support and baffle; G, feed-water injector; *b*, steam valve; *c*, water gauge; *d*, pressure gauge; *e*, receiver for soda solution; *f*, water-level regulator, which automatically governs the working of the apparatus; *g*, safety and drain valve; *h*, handle for working valve *g* by hand; *i*, feed-water valve.

The high-tension type has the same component parts as the low-tension type, and differs from the latter only in the shape of the electrodes and the dimensions of the steam dome, which in the high-tension type has the same diameter as the steam space, as shown in the view Fig. 5, which illustrates the half of an installation of eight apparatus, taking three-phase current at 6,000 volts, each apparatus being capable of generating 900 kg. to 1,000 kg. of steam per hour.

In the Revel generator, as above stated, the transformation of electrical energy into heat takes place in the body of the water contained in the space A, the water acting as an ohmic resistance inserted between the electrodes; the production of steam therefore varies with the immersed surface of the electrodes, and assumes all values between zero and the maximum, corresponding with the various levels of the water in the space A. For starting the generator the circuit-breaker is closed, the valve *i* is opened, and a small quantity of soda solution is introduced from the small receiver *e* to give a suitable conductivity to the water. When the water has reached the height of the lower edge of the electrodes the current flows through the water and commences to raise steam, the steam production increasing as the water-level rises, until it reaches the working pressure required. At this moment the regulator *f* enters into action, and the water-level, and hence the steam production, remain constant. In order to stop the apparatus the feed-water valve *i* is closed, the steam valve *b* is closed slowly, and the drain valve *g* is opened by acting upon the hand lever *h* until the ammeter has returned to zero.

When the feed water leaves a calcareous deposit it is advisable, every five or six hours, to free the boiler of the sediment deposited at the bottom of the truncated cone. This is obtained, without interrupting the working of the machine, by increasing the water feed and by acting at the same time on the handle *h*, the excess water washing away the sediment; this operation, by a suitable action upon the valves *i* and *g*, and by following closely the ammeter and maintaining the current intensity constant, is carried out without changing the water-level and without impairing the working of the apparatus.

ENGINEERING IN CHINA.

On the 23rd ult. Mr. S. W. B. McGregor, of 13, Victoria Street, Westminster, delivered before the Manchester Engineers' Club a lecture on "The Commercial Aspect of Engineering in China," from which we take the following paragraphs.

The mineral resources of China, particularly iron and coal, are enormous, but with few exceptions practically unworked. They offer an immense field for the investment of capital and supply of machinery, but await the essential conditions of foreign ownership of land and the provision of economical transport.

The electric lighting of cities and towns has very great possibilities in the immediate future, chiefly because this form of illumination is very much liked and appreciated by the Chinese. Up to 1914 this business was largely in the hands of Germans and Americans, even although in many cases British-made boilers and engines were supplied. If British electrical manufacturers wish to obtain a fair share in the coming business, they will have to revolutionise their methods and create one or more strong efficient organisations in China with adequate financial backing. In regard to small fittings, insulated wire and cable, the Japanese are making a serious attempt to capture the market. The material they are turning out is on the whole good, their business organisation is exellent, whilst they have advantages over Western nations in cheap freights, cheap labour, and the cost of copper.

As soon as conditions permit, considerable developments may be expected in cotton spinning mills and some increase in weaving, bleaching, dyeing and printing plants. The Japanese are rapidly gaining a strong position in the control of cotton mills. The Americans are making strong efforts to secure a share of the cotton-spinning machinery business.

In regard to the metal trades, steady development only is indicated, apart from a railway boom which is unlikely.

In iron and steel the figures show that the competition of the Continent and U.S.A. was increasing, particularly the latter. The bulk, if not the whole, of the U.S.A. steel trade with China, including sheets, wires, nails, bridge and constructional steelwork, is controlled by the United States Steel Products Company. This company has headquarters at Shanghai, with a number of experts in charge, and received daily, before the war, cabled fluctuations in prices from New York and London.

The German penetration of the interior, as regards engineering material, was largely effected by firms in the aniline dye and China produce export trade, whose inland connections paved the way for other business and resulted almost wholly in orders for electric lighting plant and armament requirements.

If you take a well-established, financially strong merchant house acting as agent and carrying stocks for a manufacturer who supplies one or more of his own representatives to work in close co-operation with the merchant firm, and keep in close touch with the market and consumer, you have an almost ideal arrangement for the ordinary manufacturer, which is in fact the means by which the most successful engineering business is conducted throughout the world.

The British record on the whole is one of steady progress, financial success, business based on sound foundations, and not our least asset is that we have retained the goodwill and respect of the Chinese. The trade figures show that Great Britain did 20 per cent. of the total trade of China (41 per cent., including British possessions) and 30 per cent. of the engineering and metal trade. I do not mean to say that there is not room for great improvement in our methods, but whilst criticising ourselves with the object of spurring on to greater efforts, it is well also to bear in mind the solid tangible success which we have achieved.

Japanese Shipbuilding Development.—We read in *The London and China Telegraph* that in view of the great development of the shipbuilding and engineering business of the Mitsubishi Goshi Kaisha it has been decided to alter the method of control and to form a separate company controlling these departments, including the large dockyards, at Nagasaki, Kobé and Hikoshima. The subscribed capital of the new company, which is to be known as the Mitsubishi Zosen Kaisha (Mitsubishi Shipbuilding Company, Limited), is 50,000,000 yen (5,000,000*l.*), and the paid-up capital 20,000,000 yen (2,000,000*l.*). Although the new company is a joint-stock concern, all the shares are owned by the Barons Iwasaki. The president will be Baron Koyata Iwasaki, and the intention is that the company shall remain an integral part of the Mitsubishi Goshi Kaisha, the transfer, which is to take effect as from November 1, being made merely to facilitate work and encourage initiative. The Mitsubishi Goshi Kaisha has built a number of warships, including a battle-cruiser of over 27,000 tons displacement, and a great many liners, including vessels of over 13,000 tons, for the leading Japanese shipping companies; and it may be assumed that it has been very active indeed during the war in producing new tonnage. The address of the London branch is 149, Leadenhall-street, E.C.

NOTES FROM THE NORTH.

Glasgow, *Wednesday.*

Scotch Steel Trade.—There is no falling-off in the demand for steel of all grades; indeed, if anything, it grows more intense as day follows day, and this notwithstanding the exceptionally heavy output from every steel-producing establishment in the district. Plates and sections for shipbuilding, shell bars and all other material for war purposes rank first in importance, and in order to secure this the most rigid restrictions are enforced. The heavy freight charges rendered necessary also mitigate against anything other than national work being undertaken by makers, orders being plentiful were they only able to touch them. A steady rise in prices is expected.

Malleable Iron Trade.—In the malleable-iron trade business is maintained at a very high level, makers finding themselves almost in a position "to pick and choose" among the orders offered for their acceptance, while every ton produced in the various departments secures a ready market. Both shell discard steel and ordinary ingot steel sections are being turned out in large quantity, and even with this there is scarcely sufficient to meet all the demands. Without doubt prices are bound to be affected by the increased cost of fuel, although at the moment these are all steady.

Scotch Pig-iron Trade.—Although some brands of pig-iron might almost be reckoned as out of the market, meantime there is a keen demand for those which are still procurable, delivery of which, in most instances, can be had in quite a reasonable time. The scarcity of labour alone limits the production, every available furnace being kept at full blast. It is expected that the advance in the price of coal will add at least 3*s.* 9*d.* to the cost of each ton of pig-iron, although no definite announcement on this point has as yet been made. Prices being fixed by Government, the change must, naturally, come through the same channel.

New Post for Lloyd's Surveyor.—A new appointment has just been made by the Committee of Lloyd's Register of Shipping, Mr. James Montogmerie, B.Sc., principal surveyor in Glasgow, having been promoted principal surveyor for the whole of Scotland. From the commencement of his apprenticeship with Messrs. William Denny and Bros., Dumbarton, until the present time, Mr. Montgomerie has had a most prosperous career, and is in every way fitted to fill this new position alike with honour and credit. Prior to this the different districts of Scotland were each worked independently of the other, but now all will be entirely under the supervision of Mr. Montgomerie.

British Guiana Bauxite.—The British Government is now taking a very firm stand with regard to the exploitation of the important bauxite discoveries in British Guiana, and is determined that the first call on this mineral, the source of aluminium, shall be reserved for the Empire. The British Empire Producers' Organisation has already pointed out that no further applications for bauxite lands in British Guiana are to be granted till after the war. But it appears that the Government have gone further than this. A portion of the bauxite won by holders licensed before the above regulation came into force has to be placed at the disposal of the British Government at a certain price. The British Government, moreover, reserves the right to limit the export to countries other than British, and at its discretion to prohibit export altogether. Practice, moreover, has followed principle, and a large export shipment to a foreign country of British Guiana bauxite won by a company in which foreign interests are partly represented was recently, it is stated, held up. Such evidence of a determination to conserve in future the mineral wealth of the Empire for the Empire is highly encouraging.

The Japan Iron and Steel Industries.—H.M. Embassy at Tokio writes to the effect that a law (No. 27), having for its object the encouragement of the iron industry in Japan, was passed at a recent special Session of the Diet. The law, which was promulgated on July 24, required the addition of certain minor regulations in order to render it complete; it was anticipated that these would be issued without delay, and that the law would come into force at the beginning of September. The main provisions of this measure are: (1) That iron and steel works with an output of not less than 35,000 metric tons per annum will have the right to expropriate the owners of property on which it is necessary to locate the works; and (2) that works turning out not less than 5,250 metric tons per annum will be exempt for eleven years from business and income taxes, and from all forms of prefectural, local and municipal taxation, as well as being allowed to import free of duty the machinery, &c., required for the works. The figure of 35,000 metric tons is based on the assumption that it is not economical to erect works with a furnace capacity of less than 100 tons per working day for 350 days, while the figure of 5,250 tons is based on a production of 15 tons per day for the same period, this amount being fixed for the benefit of the smaller concerns. With great industrial activity existing in the country, and the shipbuilding boom at its height, the passing of this new law has resulted in the launching of a number of new undertakings. Some of these schemes are financed and planned by important groups, which have been impressed by the large increase in the consumption of iron in Japan, especially during the last few months. A translation of the law, made by the Assistant British Commercial Attaché at Tokyo, may be consulted by British firms interested at the Department of Commercial Intelligence, 73, Basinghall-street, London, E.C. 2.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—A steady demand tends to keep pits and buyers at full stretch all the time. It is with difficulty that customers can obtain anything on the open market, for collieries seem to have practically no surpluses after meeting the heavy contract requirements. The demand for South Yorkshire hards is one of the heaviest on record, and this despite the falling away of the export trade with neutrals. All hard coal pits are having a busy time, and every effort is being made to reduce arrears to the lowest possible figure. Cobbles, nuts and slacks share the general firmness, whilst cokes maintain their consistency in keeping strong all round, with values at the limit figure. The house coal position is now regulated by some new conditions which, by requiring the intending purchaser to make a certain declaration as to his stock in hand, will prevent hoarding beyond the ordinary requirements of a household. Quotations :—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* 6*d.* to 15*s.*; seconds, 13*s.* to 13*s.* 6*d.*; and smalls, 9*s.* to 10*s.* per ton at the pit.

Iron and Steel.—With increases the order of the day it is not at all surprising to learn that there is another movement on foot in favour of increasing the maxima for pig-iron. This time the application is said to be based on the higher price of fuel, the recent addition of half-a-crown being said to affect the position so materially that a proportionate increment should be allowed to the iron firms if they are to have a return commensurate with the cost of production. Opinion varies as to the interpretation of the word "proportionate." We find that some consider the advance should be 10*s.* per ton, and others would limit it to 7*s.* 6*d.*, but the difficulty in the matter is that if an advance is conceded it will probably be the commencement of an epidemic of increases, for it will undoubtedly spread to such departments as finished iron, hoops and iron castings, and would not be without effect on the steel trade, with an inflation in the price of steel billets. As a matter of fact local opinion is seriously exercised over these periodic rises, and the large firms are finding it difficult to work at that pitch of economy which the Government officials enjoin. Their point of view will have to be taken into consideration when any discussion takes place on the question of raising the tariff for raw materials. On the other hand, it is well to note that we are making still further steps to increase the output of common iron. The Renishaw iron works, which were restarted in the earlier part of the year, are now to have another furnace blown in, whilst a substantial addition to the tonnage is expected from the relighting of the Stanton blast-furnace. All the large steel firms in this area have orders on their books for some considerable time ahead, and are not at all eager to add to their liabilities in this direction. Makers of manufactured iron also find the demand for their commodity very urgent, especially as the Government are large buyers of hoop iron for baling. The bar quality is wanted on a very large scale for important work. Heavy foundries continue to be busy, but the lighter foundries have not nearly so much work on hand. Stove grate makers keep running on renewals and also war work, such as the making of bombs, trench stoves and work for camps. A striking innovation in file-making has been made by a Sheffield firm, who have introduced a round file-grinding machine. So far it has only been adapted to certain sizes of file blanks, but it is expected that it will be so developed that all sizes will be ground in this way. By the new method the rate of production is remarkably accelerated, whilst it is also claimed that the machine-ground files are of a superior quality, cheaper in cost, and are better cut. The interest of the trade has been awakened by the Sheffield discovery, which is declared to be a process better than anything hitherto known. Cutlery firms have been endeavouring to come to terms with the men on the question of the further dilution of labour and also on the point of the introduction of more machinery. The output of war work is not so vitally concerned in this matter as the after-war trade. The aim of the manufacturers is to be prepared for the post-war demand —at the present they are not—and it is probable that labour will meet them in a generous spirit. Meanwhile there is much talk of the men receiving another substantial increase of wages. The general state of the overseas trade is keeping at a good figure when we take into account all circumstances. The latest orders are for files, saws, steel jaws, picks, shovels, spades, sickles, plane irons, high-speed and carbon tools for Allies, vices, hardware, cutlery, plate and silver work, and steel.

DRAUGHTSMEN AND THE WAR BONUS.—As a result of negotiations with the Ministry of Munitions, draughtsmen who are on time rates now come under the terms of the 12½ per cent. award, this concession having been gained by the direct representation of the Association of Engineering and Shipbuilding Draughtsmen. These negotiations have made clear that the Ministry are prepared to sanction firms granting this award to draughtsmen who are not on time rates, provided the necessary application is made by the employers. It is also understood that the Ministry of Munitions are considering making a recommendation to employers that all other draughtsmen beyond the purely time-rate men be granted this skilled workers' bonus.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The market is steady and firm, with a good deal of business passing. November allocations of Cleveland foundry pig-iron to North East Coast customers and consumers in Scotland are on a most liberal scale, and next month's home deliveries promise to be exceptionally heavy. Several producers, in fact, are understood to have already sold as much iron as they can supply of certain brands. Demand for forge quality of iron is now only very limited, consumers being well bought up to the end of the year. Foreign transactions are now small and few. For home consumption No. 3 Cleveland pig-iron is 92*s.* 6*d.*, and that price also rules for No. 4 foundry and for No. 4 forge, whilst No. 1 is 96*s.* 6*d.*; and for shipment to the Allies No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.* The stock of Cleveland pig-iron in the public warrant stores still stands at 887 tons, all of which is No. 3 quality.

Hematite Iron.—Minimum needs of inland consumers continue to be steadily met by the careful system of distribution under the strict supervision of the Control Committee, but when such requirements have been adequately arranged for there is very little surplus iron available for export. Quotations are very firm, Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and 141*s.* for export to the Allies.

Production of Pig-Iron.—For some time past the output of Cleveland foundry iron has been on a very good scale, and it has just been increased by the blowing-in of an additional furnace. This brings the total number of furnaces in operation on the North-East Coast up to 76, of which 34 are turning out Cleveland pig-iron, 42 are producing hematite, basic, spiegel and other special kinds of iron.

War Bonus to Miners and Quarrymen.—The additional war bonus granted to the Cleveland ironstone miners is to be paid this week-end at most of the mines, and next week-end to the quarrymen employed at the Weardale quarries.

Coke.—The position in the coke trade is rather peculiar. It seems to be taken for granted that the price of average blast-furnace kinds will be 33*s.* at the ovens, but up to the present an official announcement of advance to that figure is not to hand. The heavy local demand continues to be met by very ample supply. For export, both beehive and patent oven coke stand at 45*s.*, and the large inquiries on behalf of neutrals result in occasional contracts being made.

Manufactured Iron and Steel.—Producers of finished iron and steel keep very fully employed, endeavouring to cope with the huge demands of the Government and of the shipyards, and as a consequence are quite indifferent to ordinary commercial inquiries. Quotations are very stiff, but the only actual change is an advance of 10*s.* in iron ship rivets. The following are among the principal market rates to home customers :—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 19*l.* 10*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel strip, 15*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

THE CHEMICAL INDUSTRY IN FRANCE.—During the few years preceding the war the chemical industry of France made considerable headway, the proportion between imports and exports showing a marked alteration in favour of the home industry. The French chemical industry was particularly wanting in coal-tar products, especially dyestuffs and pharmaceutical preparations, also potash, saltpetre, sulphuric acid, &c. On the other hand, France has always been able to export glycerin, substances for tanning, superphosphates and soda products. At the commencement of the war there was a shortage of several chemicals particularly wanted for military purposes, such as benzol, phenol, &c., but matters quickly mended, and as early as the autumn of 1914 the Société des Produits Chimiques du Rhône commenced the erection of works for dealing with coal-tar products; the working commenced in February, 1915, and considerable quantities were ready for delivery in July of the same year. During the war a number of similar works have been erected, and it is considered quite likely that they will be able to maintain their position after the war. A company has been formed under the style of Compagnie Nationale des Matières Colorantes et des Produits Chimiques. According to an agreement with the Government three of the large factories erected by the State are to pass into the possession of the above-mentioned company at the conclusion of peace, and the new company is busily preparing for its after-war work. The production of sulphuric acid has increased to a very great extent; France's requirements of this commodity before the war amounted to some 5,000 tons per month, and the production now per month amounts to no less than 90,000 tons. There is even reason to look for a further increase in the production. The production of sulphuric acid in France prior to the war was monopolised by the Compagnie de Saint Gobain, but during the war a number of new factories have sprung up. The large deposits of raw phosphate in Tunis and Algiers will open out opportunities for using the surplus of sulphuric acid in the manufacture of cheap artificial manure.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Market.—The week-end has brought no material change in the situation on the coal market. The suspension of work at a percentage of collieries on the first day of the week is now becoming a normal feature of the market, and the only fluctuating circumstance is the number of collieries idle. Very little business is passing, shipments being almost exclusively on account of the authorities. The recent rise in the price of coal has necessarily affected coke and other materials into which coal enters, and it is expected that shortly the prices both of coke and of iron will be increased. There is a good inland demand for coal, and the transport reorganisation scheme is working a little better, although much still remains to be done before it can achieve the objects originally aimed at by the Coal Controller. Pitwood is steady at 75*s.*, and there is now a fair supply available at the collieries and at the dockside, while the arrivals of iron cargoes have also been satisfactory. In the early part of the week work at the docks was interrupted to an unprecedented extent by the heavy rains. Both loading and discharging operations were curtailed considerably, and for many hours on Tuesday there was no work at all, with the result that several ships were prevented from sailing.

Newport.—The collieries in the Eastern and Western Valleys have been fairly well employed. Managers are adapting employment as far as they can to new tonnage and cost conditions, and these are necessarily affecting outputs, but the principle of employing a reduced number of men regularly rather than a large number of miners irregularly, is undoubtedly sound, and it will probably be carried as far as practicable.

Colliery Examiners' Dispute.—The dispute with the colliery examiners over the recognition of the organisation assumed a serious phase on Wednesday. At a conference of the South Wales and Monmouthshire Colliery Examiners, held at Cardiff on that day, it was not only decided that the owners' offer be rejected, but that the examiners who are members of the organisation should cease work after Wednesday night. The owners had agreed to recognise the association and to set up a Joint Board, but the condition was added that "if, at any time, the operation of the Examiners' Association should not be in accord with the conditions of October 16, 1917, then the recognition ceases, and the question is once more open." The men apparently objected to this qualification. Representatives of owners and workmen met Sir Richard Redmayne, who represented the Coal Controller, in London, on Monday, but the attempt at effecting a settlement failed. Notwithstanding the material concessions made by the owners in order to endeavour to avoid trouble, these have now been finally rejected. About 56 per cent. of the examiners are members of the organisation, but it is difficult to forecast as to how far mining operations will be dislocated.

Welsh Miners and the Army.—Another disconcerting circumstance in the South Wales coalfield at the present is the ballot of the miners on the issue as to whether a down-tools policy may be adopted in the event of the Government proceeding with the scheme for the combing-out of colliery workers for the Army. Though the ballot was fixed for Thursday and Friday, the result will probably not be known until next week.

ELECTRO-STEEL WORKS IN GERMANY.—During the last two years 10 electro-steel works of the Lindenberg type have been built and put into operation in Germany and Austria-Hungary, their aggregate capacity being 125,000 tons annually. Another 11 works are in course of construction, their aggregate capacity being 220,000 tons per annum, and they will all be started in the course of the next few months. The Lindenberg Steel Works at Remscheid-Hasten showed a surplus for last year of 3,031,304 marks against 1,685,404 marks for the previous year. The dividend again amounts to 25 per cent., in addition to which the shareholders obtain a bonus of 10 per cent. Further 1,200,000 marks have been reserved for the issue of new shares. The German Electro Steel Company has raised its capital to 1,000,000 marks and a further increase to 2,000,000 marks is contemplated; the domicile of the company is to be removed from Berlin to Saxony.

SHIPBUILDING IN DENMARK.—A few figures showing the increase during the war of business of the Elsinore Shipbuilding Company may be of some interest. The share capital of the company is only 2,100,000 kronen, which sum was materially exceeded by the net profits of last financial year. The following table shows the increase of the business during the last four years :—

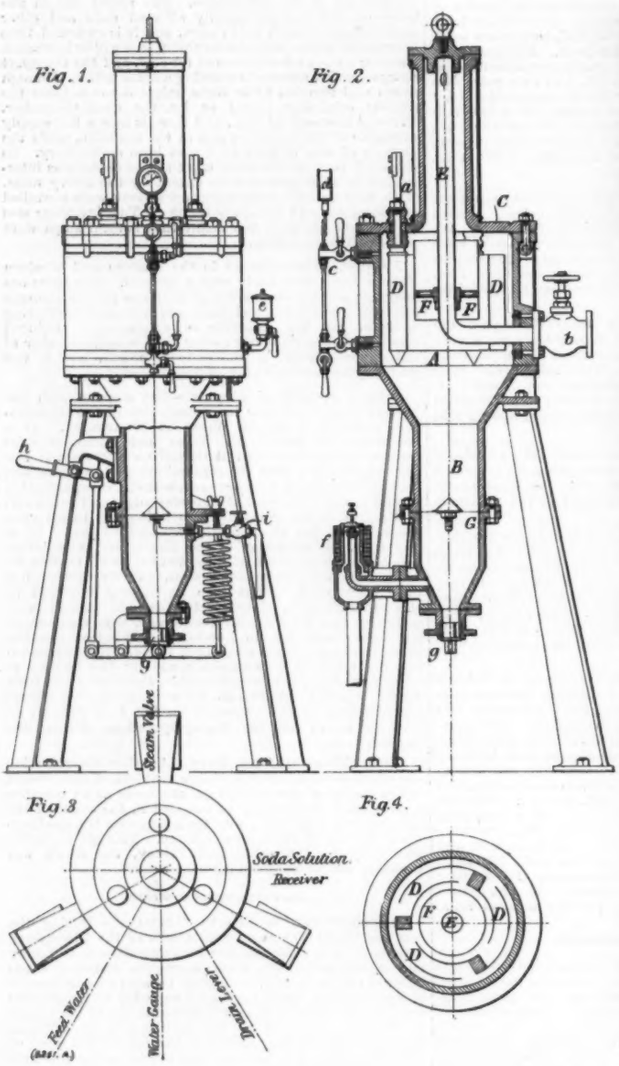
—	1913–14.	1914–15.	1915–16.	1916–17.
	kronen.	kronen.	kronen.	kronen.
Net profits	505,000	892,000	1,258,000	2,490,000
Written-off	340,000	340,000	340,000	340,000
Reserved and carried forward	28,000	270,000	172,000	1,363,000
	per cent.	per cent.	per cent.	per cent.
Dividend	6	10	20	25
	kronen.	kronen.	kronen.	kronen.
Reserve fund	525,000	525,000	775,000	825,000
Bank credit	619,000	536,000	1,028,000	1,030,000
Stores	420,000	620,000	947,000	1,617,000

Large extensions are contemplated, including a 10,000-ton floating dock. (18 kr. = 1*l.*)

THE REVEL APPARATUS FOR GENERATING STEAM BY ELECTRICITY.

CONSTRUCTED BY MESSRS. LUIGI BOSELLI AND CO., ENGINEERS, MILAN, ITALY.

(*For Description, see Page* 468.)



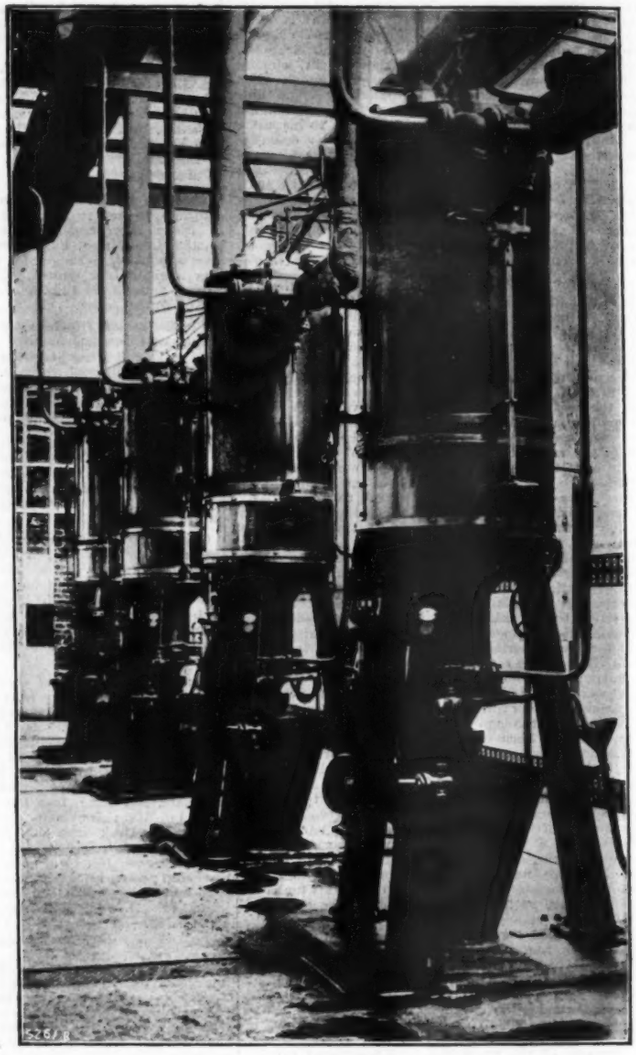


FIG. 5.

COAL TAX IN AUSTRIA.—The introduction of a coal tax has been announced in Austria on similar lines to the German coal tax, which came into operation a couple of months ago. It will probably be fixed at 20 per cent. of the value, as in Germany, or perhaps a little less, and it is expected to yield a revenue of about 4,000,000*l.* per annum. A special agreement will be made between Austria and Germany with reference to coal exported from one country to another so as to avoid double taxation.

TRAFFIC INCREASE ON THE PENNSYLVANIA RAILROAD.—As a result of the campaign to make freight cars do more work, and of the willingness of shippers to aid in this direction, the average load carried per car in July this year was 33.51 tons. In July, 1916, the average load was 29.57 tons. The improvement this year was 3.91 tons per car, or more than 13 per cent., which means that the shipping public made 13 per cent. better use of the freight car facilities of the Pennsylvania Railroad. This effected a saving of 81,268 cars in the number required to handle the traffic of the Pennsylvania Railroad Lines East during July of the past summer. The saving achieved by this co-operation on the part of shippers not only enabled the Pennsylvania Railroad to handle a much larger amount of commercial business than would otherwise have been possible with the facilities at hand, but also aided materially in rendering efficient military transportation service to the Government. This applied especially to the carrying of materials for the construction of the various cantonments which were in process of building throughout the summer months. While definite figures are not as yet available for any period later than July, it is the belief of the management that when the results for August and September are ascertained it will be found that an even greater improvement in freight-car loading has been achieved, and that this has in a material degree contributed to the smooth handling of the large numbers of troops which have been transported in recent weeks with little or no disturbance to regular traffic.

BRITISH STANDARDISATION RULES FOR ELECTRICAL MACHINERY.—We have received a copy of the new edition of the "British Standardisation Rules for Electrical Machinery" (excluding motors for traction purposes), being Report No. 72, 1917, of the British Engineering Standards Committee. The first issue of this report was made in October, 1915, and special attention is directed to the new form in which these rules appear. In line with all new and revised specifications and reports issued by the committee, this publication is octavo size and is issued at the uniform price of 1*s.* net. French, Italian and Spanish translations of this report will be available shortly. The committee is particularly anxious that the issue of its publications at the flat rate of 1*s.* should become as widely known as possible, for it is hoped that this will lead to their very extensive dissemination amongst engineers, managers, designers, draughtsmen, foremen and, in fact, all those engaged in the engineering and allied industries. The principal modifications introduced during this revision of the Rules are as follow: The permission to use the thermometer method of measuring the observable temperature of continuous-current shunt-wound stationary field coils, provided the maker can show that if the resistance method had been employed the limits of observable temperature and observable temperature rise permitted by the rules would not have been exceeded (clause 68). The thermometer method is in this case penalised with a 5 deg. reduction in the permissible temperature limits (clause 67). In the first edition of these Rules the use of embedded temperature detectors was permitted for large machines, but in the present Rules measurements made with embedded temperature detectors are no longer to be considered as an essential part of the acceptance tests. The excess current tests have been reduced in the case of machines for continuous service from 100 per cent. to 50 per cent. (clause 79). A few alterations have been made to the high-pressure tests and a clause has been added dealing with the application of a high-pressure test to a machine which has been out of service for some time and to which it is desired to apply a high-pressure test to ensure that the insulation should be in sound working condition before the machine is put back into service. In this case it is stated that the test pressure should be 75 per cent. of the test pressure required in the case of a new machine. The Rules have been rearranged, and an introduction, the object of which is to explain briefly how the Rules should be used, has been included.

KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE; GREAT CENTRAL RAILWAY.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(*For Description, see Page* 456.)

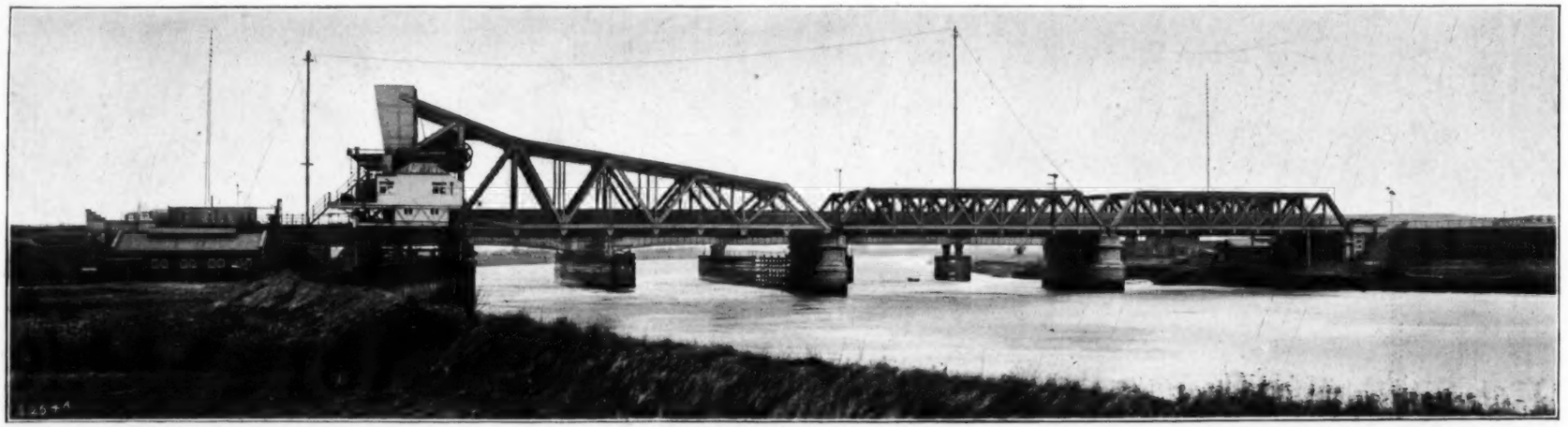


FIG. 41. GENERAL VIEW OF THE BRIDGE.

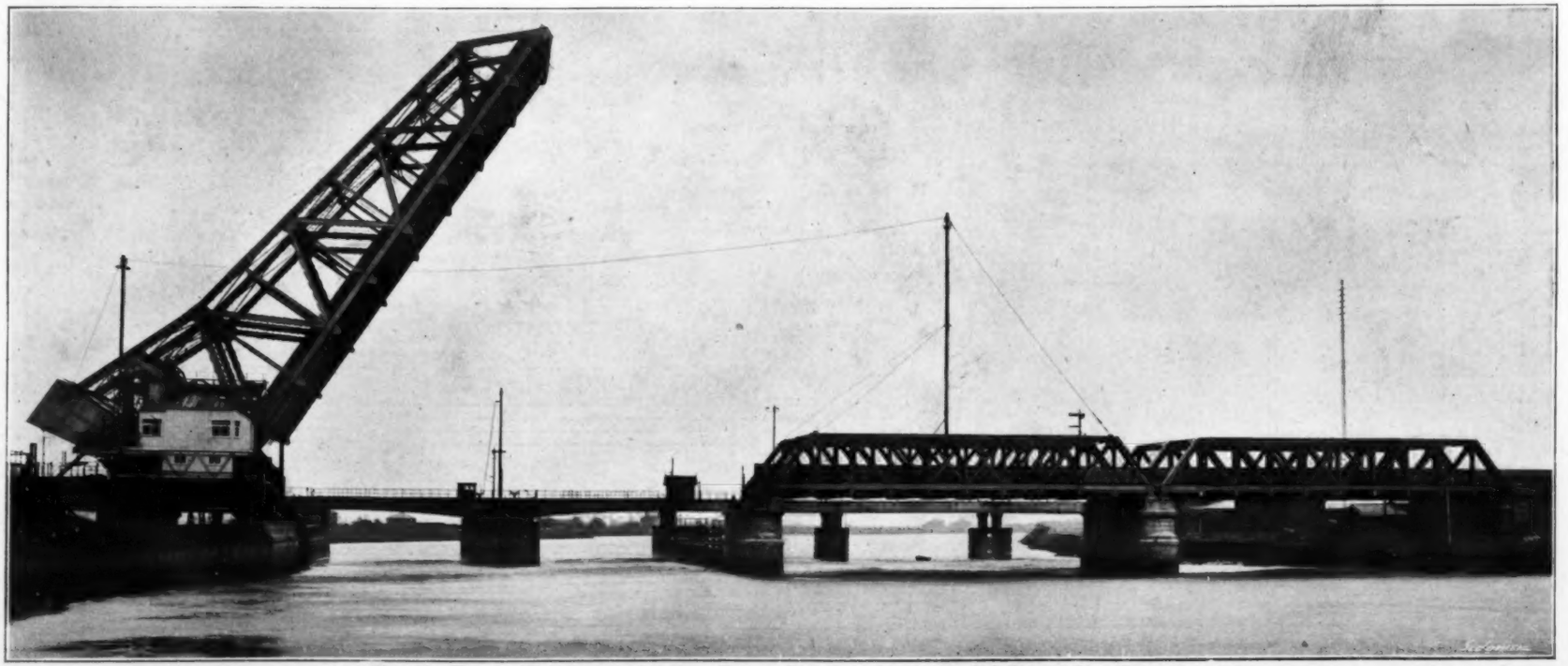


FIG. 42. VIEW OF BRIDGE WITH SCHERZER ROLLER LIFT SPAN OPEN; THE OLD BRIDGE SEEN BEYOND.

(*To face page* 462.)

THE KEADBY RAILWAY AND HIGHWAY SCHERZER ROL

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILL ARRO

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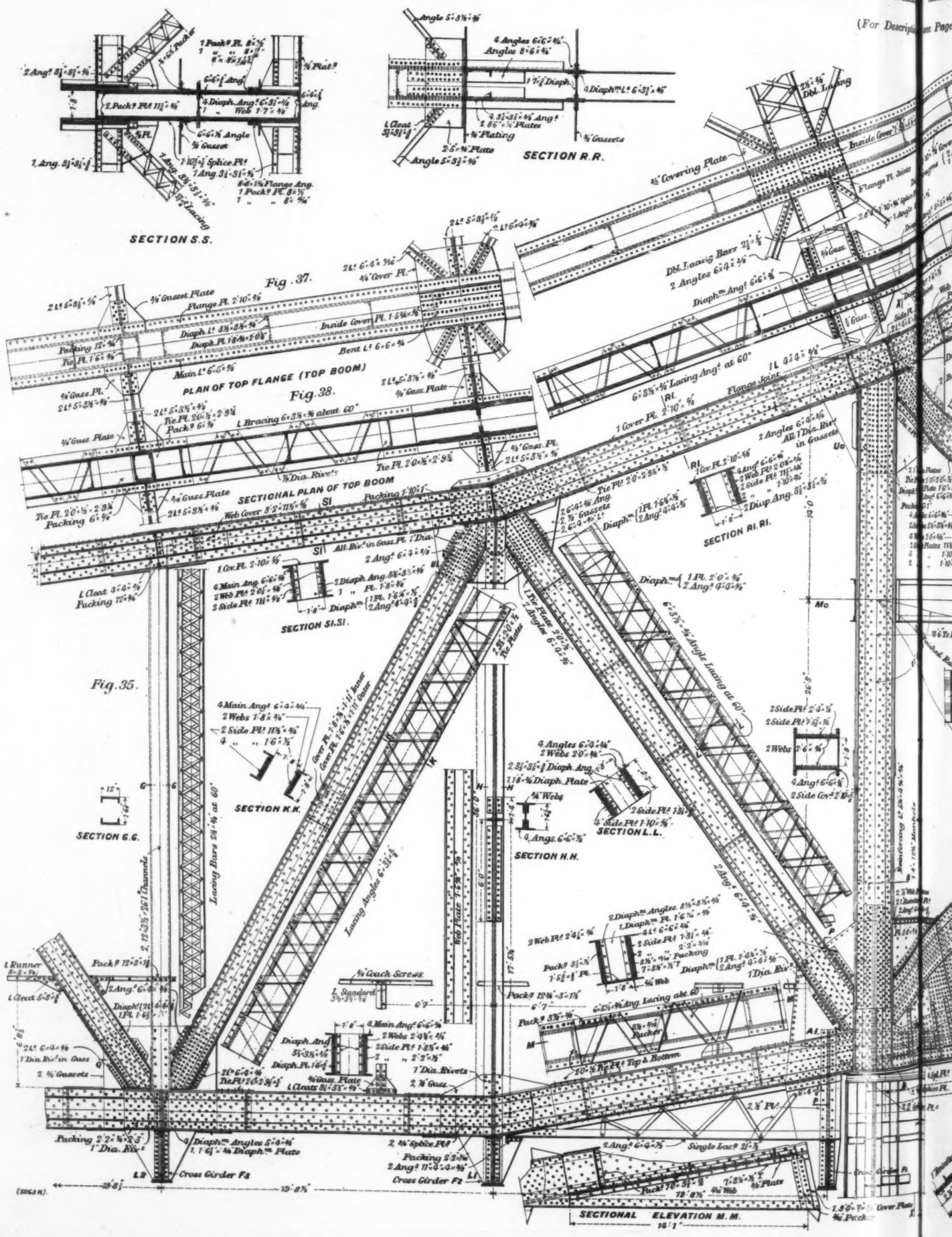
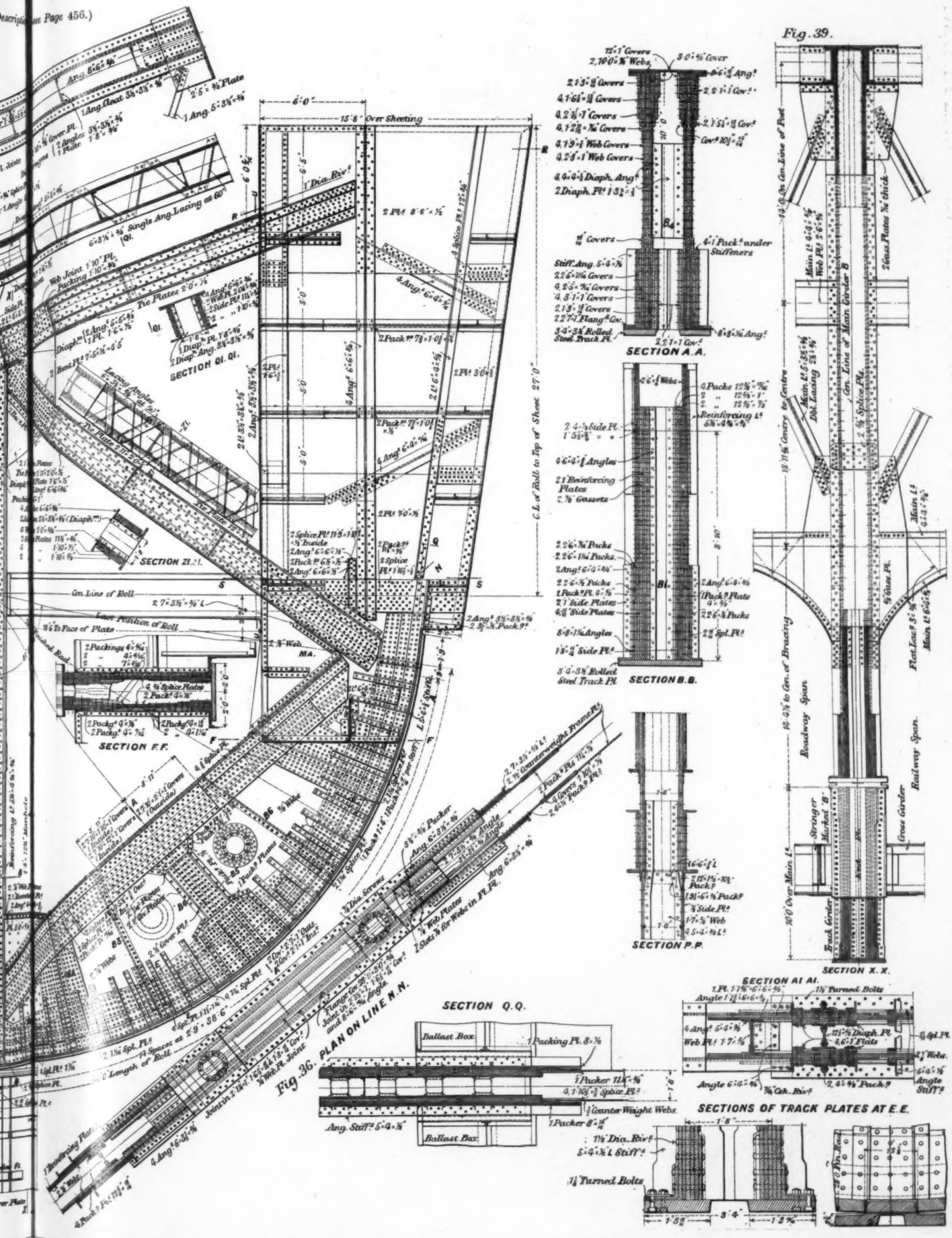


ROLLER LIFT BRIDGE; GREAT CENTRAL RAILWAY.

ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(See Page 456.)



KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE; GREAT CENTRAL RAILWAY.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(*For Description, see Page* 456.)

FIG. 43. THE SCHERZER ROLLER LIFT SPAN COMPLETED.

(*To face page* 463.)

AGENTS FOR "ENGINEERING."

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For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2	4	6
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Thin paper copies	£2	0	6
Thick ,, ,,	£2	5	0
For all other places abroad—			
Thin paper copies	£2	5	0
Thick ,, ,,	£2	9	6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS | "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3863 and 3508 GERRARD.

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With One Two-Page Plate and Two One-Page Plates of the KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE; GREAT CENTRAL RAILWAY.

NOTICES OF MEETINGS.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Monday, November 5, at 5 p.m., a general monthly meeting of the members will be held.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 6, at 5.30 p.m. Address by Mr. Harry Edward Jones, the President, and presentation of medals awarded by the Council.

THE RÖNTGEN SOCIETY.—Tuesday, November 6, at 8.15 p.m., at the Royal Society of Arts, John-Street, Adelphi, London. Presidential address on "The Part Played by X-Rays in the War," by Captain G. W. C. Kaye, D.Sc., followed by an exhibition of the most recent apparatus. Visitors are invited.

THE FARADAY SOCIETY.—Wednesday, November 7, from 5.30 p.m. to 7 p.m. and from 8.30 p.m. to 10.30 p.m., at the Royal Society of Arts, John-Street, Adelphi, London, W.C., a general discussion will be held on "Pyrometers and Pyrometry." Sir Richard Glazebrook, C.B., F.R.S., Past-President, will preside over the discussion. Dr E. F. Northrup (Trenton, N.J.) will send in a communication entitled "High-Temperature Production and its Measurement." Dr. Ezer Griffiths and Mr. F. H. Schofield (National Physical Laboratory) will read a paper on "Pyrometer Standardisation." Mr. R. S. Whipple (Cambridge) will read a paper on "The Advantage of Burying the Cold Junction of a Thermo-Couple as a Means of Maintaining it at a Constant Temperature." Mr. Richard P. Brown (Philadelphia) will read a paper and give a demonstration on "The Automatic Control Measurement of High Temperatures." Professor J. O. Arnold, F.R.S. (Sheffield), will speak on "Pyrometry Applied to the Hardening of High-Speed Steel." Professor F. G. Donnan, F.R.S., will speak on "Optical Pyrometry in Non-Ferrous Metallurgy." Mr. Cosmo Johns (Sheffield) will speak on "Determining the Temperature of Liquid Metals by means of Optical Pyrometers." Dr. W. H. Hatfield (Sheffield) will read a paper on "Pyrometry from the Standpoint of Ferrous Metallurgy." Dr. A. McCance (Glasgow) will read a paper on "Temperature Determinations of Liquid Steel." Mr. H. Watkin (Stoke-on-Trent) will read a paper on "The Measurement of High Temperature by means of Pottery Materials." Mr. C. B. Darling will read a paper on "Base-Metal Thermo-Electric Pyrometers." Dr. J. W. Mellor and Mr. G. E. M. Stone will also contribute to the discussion. Instruments will be exhibited by Automatic Electric Furnaces, Limited, Mr. Richard P. Brown, the Cambridge Scientific Instrument Company, the Foster Instrument Company, Messrs. Hadfields, Limited, Mr. H. L. Heathcote, Messrs. Adam Hilger, Limited, Mr. Robert W. Paul, Messrs. Siemens Brothers and Co., Limited.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 7, at 8 p.m., at the Royal Institution, Colquitt-Street, when the President, Mr. Harold Dickinson, M.Inst.C.E., M.I.Mech.E., M.I.E.E., will deliver his inaugural address.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 8, at 6 p.m., at the Institution of Civil Engineers, Great George-Street, Westminster, S.W. Inaugural address of the President, Mr. C. H. Wordingham. Presentation of premiums.

THE ROYAL SANITARY INSTITUTE.—Friday, November 9, at 7 p.m., in the Council Chamber, Town Hall, Newcastle-upon-Tyne. Discussions will take place on "Standards of Meat Inspection under War-Time and other Conditions," to be opened by Mr. Thomas Parker, F.R.C.V.S. (Veterinary Officer and Inspector of Provisions, Newcastle-upon-Tyne). Saturday, November 10, at 10.30 a.m., on "Structure in Municipal Housing" (illustrated by exhibit of building materials), to be opened by Mr. John H. Mole, Sanitary Inspector and Surveyor, Chester-le-Street R.D.C.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN: NEWCASTLE BRANCH.—Friday, November 9, at 7.30 p.m., at the Connaught Hall, Newcastle-upon-Tyne, a paper will be read by Messrs. F. Hope and A. M. Hepel on "Technical Education of Engineers and Shipbuilders."

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, NOVEMBER 2, 1917.

THE TRAINING OF APPRENTICES.

FEW will dispute the accuracy of the diagnosis of present industrial conditions made by the Master Cutler at the discussion on engineering training held in the Institution of Civil Engineers on the 25th ult. Mr. Ellis said that peace would find us confronted with ruined industries unless effective steps were taken to increase output and efficiency. The fact that the large hall of the Institution was crammed to a condition of standing room only afforded cogent evidence that similar apprehensions are widely held, and may, we hope, be taken as evidence of a "will" to progress sufficient to overcome the resistance which will be offered actively by vested interests and passively by the mere inertia of long-established routine. The deputation from the North-East Coast to Mr. Fisher on the 18th ult., the proceedings of which we report on page 467, may be taken to confirm this view.

Mind is the main factor in the production of wealth, and a first essential to success will be the enlistment of the active co-operation of the brains of the workmen. Workshop employees have too frequently been regarded in the past as mere "hands." They have been paid as such, and have often been most unfairly treated when they have themselves devised important improvements in manufacturing methods. In part at least this has been responsible for the procedure, still unfortunately prevalent, in which the employee's ingenuity is devoted to actually diminishing production and to bringing to naught all efforts for greater output made by the management. Thus when the management of a certain firm recently succeeded in making on the turret lathe a delicate machine part previously made on a precision lathe, there was an organised effort on the part of the older workmen in the shop to spin out time on the other components of the machine so as to maintain the total labour cost at its previous value. The problem before the employers is to divert the ingenuity thus expended on aims indefensible either in economics or ethics into channels which will be profitable to the community. Possibly the solution has been found by Mr. Ford, though his system has not, to say the least, been enthusiastically welcomed by organised labour.

In this country and in America a career has in the past been open to every engineering recruit, whatever his origin or training. Men have risen from the ranks to the highest positions in the profession. In certain branches of engineering however, chances of this kind are fewer than formerly owing to the increasing importance of the part played by a knowledge of scientific principles in every field of manufacture. So long as practice was dominated by rule of thumb, a good mechanic was as well equipped as his *soi-disant* educated competitor for the solution of such novel problems as might present themselves. When bridges, for example, were proportioned by rule of three from models tested to destruction, a very small equipment of mathematical knowledge sufficed for all the needs of a designer. Now very extensive mathematical attainments are absolutely necessary in the bridge engineer who aspires to design the large-span structures which are required. Other lines of promotion from the ranks still remain open, as is daily exemplified, but it is important that no route of advancement should be closed. We shall require all our ability to liquidate the enormous debt now being piled up, and careers must therefore be kept open to the talents. In general, Government departments lag much behind private establishments in enterprise, humanity and foresight, but the Admiralty system of training and promoting apprentices has for many decades been an example to us all. All youths entering the dockyards as apprentices are compelled to attend classes, at least for a length of time sufficient to prove whether or not they have any aptitude for the theoretical side of engineering and naval architecture. The best students are pushed forward step by step to the higher educational establishments, and become our naval constructors. The others return to the shops, and are not compelled to attempt to pursue studies for which they have no natural aptitude. The system in vogue in the engineering department of the Midland Railway Company is also farsighted and satisfactory. Both pupils and ordinary apprentices are taken (without fees), and the more promising of both are placed in a special privileged class to which facilities are given for acquiring varied knowledge and experience. Private firms have commonly treated their boy labour on much less liberal and enlightened lines. Too often no real attempt has been made even to teach the lad his trade, and though some firms of late years have inaugurated schemes of rewards for good work at evening classes, these have at the best fallen far short of the standard set by the Admiralty, and in too many instances the awards have been grudgingly made, in deference rather to a desire to be in the movement than with any real enthusiasm for it.

Speaking at Thursday's meeting, Professor Dalby

observed that until quite recently the possession of scientific training was actually a bar to employment in engineering works. Not many years ago, indeed, certain firms loudly proclaimed that they "would not have a scientific man about the place." Those that maintained this policy have for the most part gone into bankruptcy. The demurrer was in part, no doubt, due to the well-recognised difficulty of applying theoretical studies and laboratory experience directly to practical problems. An alloy made with chemically-pure ingredients may show excellent qualities in the laboratory which are by no means duplicated by a nominally similar material made on an industrial scale with raw materials of the ordinary commercial quality. Similarly a good computer may, as German experience has repeatedly shown, prove a very indifferent designer of structural steelwork. There was, however, another element at work, distrust of scientific attainments, and this unfortunately still persists. Firms objected to taking into their works men, and particularly clever men, who could not be relied upon to remain with them indefinitely. Some employers, again, whilst encouraging and assisting their apprentices at class work, drew the line when a desire was expressed to compete for Whitworth exhibitions or scholarships, on the ground that they were likely to lose the services of a successful candidate. A policy at one time rife on the Tyneside was based on similar narrow and self-centred principles. If a draughtsman were found to be applying for work with another firm he was dismissed forthwith. Naturally few of the best remained long where this inequitable policy was pursued; and the firms in question lost in this way the services of the ablest and most enterprising of their junior staff. A more enlightened and, in the long run, more profitable view was that taken by a leading American firm when the question was raised whether certain assistants in important experimental work should or should not be told the objects of the research. There were in this instance certain strong grounds for the policy of secrecy, yet in the end it was decided against, on the ground that some of the young men concerned would later on be the responsible engineers of the company, and it would be of advantage to have them as adequately equipped as possible.

It is in general our older-established firms which have been thoughtless in this regard. They have persistently refused to enhance the value of a junior employee by giving him opportunities of acquiring knowledge and experience; and hence, when the day arrives when senior positions are vacant, the promotions have had to be made from poorly-taught pupils of their own, or it has been necessary to poach upon the stock of better-trained men turned out by concerns of greater breadth of vision. We shall never pull our full weight in the international competition for trade until employers as a body are less meticulously concerned as to their momentary interests, and more disposed to view such problems from the standpoint as to what is best in the long run for the industry as a whole.

Professor Dalby claimed, and we think rightly, that although the annual output of our technical colleges has in the past not been one-tenth that of Germany, yet there has been little fault to find with the quality. Our own observation would confirm this, as the training given is less specialised than is usual in the Fatherland. Our system has of course the drawback of rendering the newcomer from the colleges of less immediate use in actual works than his German rival, but the broader foundation affords a much superior basis for the superstructure to be finally raised thereon.

To Mr. Berriman, of the Daimler Company, and to Mr. A. P. Fleming, of the British Westinghouse Company, belong the credit of Thursday's successful meeting. Both the companies mentioned have shown themselves in the van in the matter of the better training of our engineer "aspirants." The movement responsible for the meeting originated in a conference of engineers and educationalists held at the Board of Education last winter. This led to certain proposals being put forward in which provision was made for the establishment at the Board of Education of a bureau specially concerned with technology. The credit of Government departments, never high amongst those who had to deal with them in other than a political capacity, has suffered still more from the experiences of the past three years, and strong objection was accordingly expressed to placing the new movement under direct Government control. This, however, can only be avoided if engineering firms will themselves finance the proposals submitted to the meeting. These provided for the co-ordination of engineering training, the fostering of apprenticeship as a national institution, and the securing of a higher appreciation in our industries of education of university rank. A central authority is to be established where parents and guardians may obtain reliable information as to the best course for them to take on behalf of boys wishing to become engineers. Finally, scholarships are to be founded to enable the best talent to rise to its proper level. If this scheme can be adequately financed on a voluntary basis, it will be greatly to the credit of the profession. A powerful committee for giving effect to the scheme was appointed at the meeting.

Naturally there will be little advantage in the proposed improvements in the training of young engineers unless our manufacturing firms determine to profit by the product. This will involve a complete abandonment of the accountant's little pleasantry of classifying as non-productive all services but those of the manual labourer. In the past the drawing office has too commonly been starved, whilst foremen have been overworked and underpaid. An inadequate and incompetent drawing-office staff can cause immense losses, which are the worse because drawing-office blunders may often be concealed as successfully as those of the doctor, who is said to bury his underground. The accountant or "business man" who grumbles at the level of the drawing-office expense account, and succeeds in reducing it, may easily fail to detect an increase of ten times the amount of the saving in shop costs directly due to his misplaced zeal for economy. The difference between a good and a bad draughtsman is soon reflected in shop costs. In this country, owing to the insistence hitherto placed on shop experience, our draughtsmen have, on the whole, been far superior in machine design to their continental competitors, who have commonly come direct from a technical school and gained their experience wholly in the drawing office. Quite recently one such continental draughtsman, who was responsible for the production of certain plans sent to the licencees of his firm in this country, professed that he was an "engineer" and that the question of shop costs did not concern him, but was merely a matter for the shops. His responsibility ceased, he contended, when he provided designs which would work, and it was "up to" the shops to construct them as best they could.

Experience during the past three years has also shown great waste in the shops owing to the inadequacy of the shop management. Foremen have been far too few for efficiency. Being classed as "non-productive," it has seemed good to the "office" to reduce this non-productive labour to a minimum, and the growth in shop expenses has been consequently enormous. The difference in output when men find every detail of the work thought out for them beforehand, and when they are left to their own devices to do the best they can, is enormous. A man who has to bend down in a strained position for hours chipping a heavy casting will get through much less work than if his foreman has time to see that the work is presented to him so that it can be conveniently got at. In a shell factory, again, it was found that the output was nearly doubled when the blanks were placed on trestles at lathe height instead of being tumbled in a heap on the floor so that the machinist had to stoop and lift each some 3 ft. or so. An adequate shop staff paying attention to items of this kind will pay for itself many times over, although the accountant may be confronted by an alarming increase in his "non-productive" expenditure.

The proposed improvements in methods of engineering training will, if they come to fruition, provide a large number of competent recruits for both the shop staff and the drawing office, and we firmly believe that salvation for the engineering trade will be found solely in seeing that the services of these clever young men are utilised to the full. The manager of one large and very successful firm has, we are interested to hear, announced that he does not anticipate in the future having any use for a head foreman who is not worth a salary of 500*l.* a year. Of course the firm here in question is a very large one, but even among large firms there was thirty years ago a widely held opinion that no foreman, whatever his abilities, should receive more than 45*s.* a week. The position accordingly ceased to offer any attraction to the abler men, save as a possible stepping-stone to promotion elsewhere.

THE BIRMINGHAM EXHIBITION OF WOMEN'S WORK.

The Exhibition of Women's Work now being given at Birmingham by the Technical Branch of the Ministry of Munitions' Labour Supply Department adds items to the volume of examples given in previous exhibitions; but in substance it adds little to what was known of the applications of women's work, for indeed there was little left to know. Yet it is by no means the least instructive of the series to engineers, nor the least opportune.

Next to the volume and range of work that is covered by the specimens exhibited perhaps the most satisfying feature of the exhibition is the assurance that it gives of the work being genuinely done by women. As we pointed out last week, instances are not unknown of exhibitions purporting to refer to women's work in which specimens have been shown which, though in other works similar work was being done, and done equally well, by women, were themselves made by men. Nothing could be more damaging to the confidence that such exhibitions are intended to inspire; it is no small gain to the engineering public to know that in the exhibitions given by the Ministry of Munitions nothing is admitted that is not certified to be the genuine work of women. In every instance the firm in whose works the specimens are produced is required to give an assurance before they are placed on show that they were made by women; and the popularity of the exhibitions among mechanics who are themselves employed in the works in question provides the most independent check on the accuracy of such claims. When the large number of separate articles made in any works is considered, and the wide selection that appears in the Ministry's exhibitions, it is indeed easy to imagine that a slip might have been made in passing work from store, and here and there a piece have been unintentionally let through which had actually been made by a man. It is believed, however, that no such piece has been allowed to get through, and engineers will feel grateful to their colleagues in the Ministry and in the works to whose care this important assurance has been due.

Perhaps the most important of the new features of the Birmingham exhibition are the several groups of work done in the Training Schools and Instructional Factories of the Midlands. These schools vary in size and in the number of branches that they teach; but between them they cover practically all operations in the machine shop, acetylene welding, some smiths' work and woodwork, moulding and core-making, and simple drawing, tracing and blueprinting. Their particular merit is that the work done by the pupils is made, wherever possible, for use, and the training combines more or less, to an extent that varies with the excellence of the institution, the benefits of instruction and of shop life. The initiation of the pupil into the customs of shop life—not necessarily all of them, but those that tend to good discipline—is not perhaps of the first importance in the training of women, to whom shop discipline comes more easily than to men, though even to women it is not without its difficulties. But the advantage of having shop discipline, so to speak, taught at the same time as shop arts is felt most strongly in the introduction of discharged soldiers into industry. This is a problem as important to national necessities, immediate and future, as the mobilisation of woman-power, and its solution is a national obligation, altogether irrespective of the country's needs. It is a problem that

particularly affects engineers, not only because of the vast extent and variety of their industries, but also because those who as engineers have remained in civil life have enjoyed an immunity from dangers that discharged soldiers have undertaken, and owe to those who have borne the burden the duty of helping them in every possible way to earn a creditable and useful living. To earn a living as an engineer demands nowadays more than mechanical skill from all whose skill is not far above the average. A living can be earned by average work only by the co-operation of men and the subdivision of work; and such co-operation involves the same sort of discipline as is required in a rowing eight or a football eleven, with the added difficulty that the race extends through each and every entire working day.

These may sound platitudinous reflections; but in fact they are by no means unnecessary. It is a matter of common knowledge in the engineering trades that attempts made after the South African War to introduce discharged soldiers into industry were notably and unexpectedly disappointing, because many of the men would not stick regularly to their work. Looking back on what happened, one sees that it was not natural that they should; and looking forward at what may be expected of the present introduction of discharged soldiers, one sees no prospect of a better result unless shop discipline is regarded as a matter not simply of individual virtue, but of a training or drill which mostly does not come by nature and has to be learned. A soldier has epochs when he is under a stricter discipline than any workman, enforced by heavier sanctions; but these moments are discontinuous, and he does what he likes in the intervals. Shop discipline, on the other hand, if it is to be of any good at all, must be continuous; and if the change of habit is not acquired before a man is turned into the actual commercial shop, it often will not be acquired at all, and the man will for industrial purposes be wasted. And for that reason a man has a much better chance of getting his proper shop balance if he is taught it at an avowedly instructional institution, where, if the discipline is strict, it will nevertheless be intelligible and admittedly benevolent; where it is possible to explain to a man, as it is seldom possible in a shop, that the habit of discipline is part of what he has come there to learn, and where he can simply include it in the bundle of arts that of his own free will he is seeking to acquire, instead of leaving it to settle into the body of disagreeable circumstances that every sensible man studies to avoid when he can. This view is taken by many of the training institutions, and their men turn out regular and good timekeepers, as they often do not when they are shot straight into the shop.

It is to be remarked further that the hours of work offer an advantage over those of many shops in being no longer than will permit men to work their hardest. They run for the most part about a 50-hour week, and a ten-minutes' break is introduced into each turn; precisely the conditions that on the balance of experience are usually the most favourable to intensive and attentive working. At present this advantage can only be had in a minority of shops, and counts therefore all the more in favour of the institutions where it can be enjoyed.

The mechanical operations taught in these institutions range from simple repetition work on automatic and semi-automatic machines and capstan lathes up to work of high accuracy, such, for example, as making master-gauges for the contour of pins for the use of the National Physical Laboratory without any sort of jig or similar assistance. The period of training varies with the work for which the pupil is being prepared and his or her aptitude; but, broadly, it runs from a week to six or eight weeks for all ordinary work, and from two to six months for the most accurate work. Many examples are shown of work involving screw-cutting and turning to 0.001 in. in centre lathes. This work women do for actual production after four to six weeks' training; and apparently a month is sufficient to teach them to turn out work involving the use of seven tools in a capstan lathe, including the actual setting-up of the tools. In some schools, indeed, every capstan operator is made to learn the setting-up of her own tools; and in at least one, the Loughborough Instructional Factory, the management, by a self-denying ordinance deserving of the utmost praise, staff their tool-room exclusively with their own pupils, who are constantly passing out into industry and being replaced by other pupils who are completing their course. In this factory some 250 pupils are constantly under training.

The specimens shown include oxy-acetylene welding for aeroplane and pipe work, in which, for instance, a six-way pipe-weld is shown made by a woman of five weeks' training, and a thoroughly sound section of a cast-iron weld made by a girl after two weeks' training; wood and sheet-metal work for aeroplanes, marked out and made by hand from drawings, by girls of six weeks' training; capstan and centre-lathe work; a large variety of gauges, such as a horseshoe gauge for 18-pdr. shrapnel, cut up, filed, lapped, &c., to an accuracy of 0.0002 in., by girls of two to three months' training; contour gauges, screw gauges, &c., all made by girls under a lady instructor; and essential parts of a pitch-measuring machine at present under construction for the National Physical Laboratory.

The 80 specimens which this institution shows are only a fraction of the varieties of work in progress; and the fact that the entire tool-room should be constantly and exclusively staffed by women and discharged soldiers who have never had more than a few months' training, and that work of the character described should be turned out constantly for use in industry, is final and conclusive evidence that there is no substance in the suggestions that work in the tool-room and on centre lathes involves a skill beyond women's abilities. As has been said repeatedly, no pretence could be made that in a few months a woman or a man could acquire the experience and knowledge of an all-round first-class fitter, who from his own resources could pass from one job to another without direction or advice. But in the production of munitions what is demanded most often and most widely is not the versatility of an experienced man, but accuracy and trustworthiness in definite operations. Examples such as those from the Loughborough factory show that in practice, as perhaps might have been expected in theory, women's delicacy of touch, patience, and tolerance of monotonous processes enable them very rapidly to become the full equals of men in whatever individual operations they have been taught. It should be added that the instructional factories and the like are not intended to supply the entire trade with the labour required, but only so much of it as has not the convenience and disposition to train women and discharged soldiers for themselves. Many firms, however, find it to their advantage to do their own training, and the results are shown in all groups of the exhibition. One exhibit, for instance, shows a 2-in. shell tap from the bar to the final product, every operation on which, except the initial cutting-off of the bar by a boy and the hardening, for which the shop is not convenient for employing women, is done by women of a few weeks' training.

The present exhibition is thus of particular value as showing not only the product of the work of women and discharged soldiers, but also, in much greater detail than before, the mechanism by which it is produced, and the extreme rapidity with which it can be applied to the purposes of practical manufacture. This evidence, as pointed out above, comes at an opportune time. At the second of the three cinematograph displays, given on Sunday evenings in connection with the exhibition (the third of which will be held next Sunday, under the chairmanship of the Bishop of Birmingham), Captain Bell, of the Ministry of Munitions, said plainly that the available supply of skilled labour in the engineering trades of this country is now fully occupied, but that, nevertheless, more workers are wanted, and will continue to be wanted in increasing numbers till the end of the war. That is a plain statement, made on authority that cannot be questioned. It admits of only one practical conclusion, which in these columns has been drawn repeatedly for many months past. The restrictions on the employment of women for those purposes to which their labour has been shown to be applicable must be removed wholly and unreservedly, as they have not been removed up to now. Men skilled in their trades can ask reasonably that they shall not be transferred to national service in order to admit other men of military age and fitness to their places. With this single reservation, they can only ask to be relieved of national service outside their own trade if they cannot be replaced in their present work. No man is to be displaced from his work unless work of more urgent public importance is waiting for him; and no man for whom such work is waiting, and whose present work can be done by a discharged soldier or a woman, can be left where he is without betraying the interests of the nation, sacrificing its soldiers at the front, and prolonging the war. Such is the only possible conclusion from Captain Bell's frank and uncoloured statement. It is earnestly to be hoped that the Ministry of Munitions, by whom we must assume the statement to have been authorised, will at last take the clear and consistent course that the circumstances so urgently demand; and we feel no doubt whatever that, when once they have made it clear that they are doing so, they will be supported by the enormous majority of engineers, who are as patriotic and as sensible as any other citizens.

EYE PROTECTION AND SIGHT FILTERS.

In our ancestors were liable to strain their eyes by having to work in insufficiently-illuminated rooms, the development of electric lighting and the general industrial development of our age are more apt to endanger our sight by the effect of intense and trying illumination, and we have learned to understand that the greatest dangers to our eyes lurk in radiations which are invisible in more than the ordinary sense. In the strict sense all radiations are of course invisible as long as they are not stopped, absorbed or reflected in some way; the "optically empty" medium does not betray the rays of light passing through it, and would probably not suffer from the light if such a medium were endowed with consciousness. But the different organs of our eye may suffer before we become conscious of light sensation, and the investigation of the physiological effects of light is difficult and fraught with danger to the investigator. When we wish to consider these phenomena we must not speak of light generally, but must define and classify the radiations, and the simplest way of doing this is to classify them as to wave-lengths. To arrive at a conception of wave-length we must split the ray or beam of light up into something which need not be much more directly present in it than the greenish poisonous chlorine gas of our laboratories is present as such in the salt we put into our soup. The spectrum shows the eye the beam of white light spread out into a luminous band shining in brilliant colours, and physical and chemical tests teach us that the visible band is only a small portion of the invisible band, and that the apparently simple ray is anything but homogeneous. We measure the wave-lengths in Angström units ($1\,AU = 10^{-10}$ m. $= 10^{-8}$ cm. $= 1$ micromillimetre, or millionth of a millimetre $= 1\,\mu\,\mu$), or in microns, μ ($\mu = 0.001$ mm.). Measured in μ, yellow light has the wave-length 0.59, and the visible spectrum ranges from about 0.38 (violet) to 0.75 (red). Radiations of wave-lengths shorter than violet light are known as ultra-violet, Schumann rays (0.1 μ) and Lyman rays; then follows a long, relatively unexplored gap, until we come to Röntgen rays, of the order of 0.0001 μ or less. Infra-red waves longer than red rays, on the other hand, have actually been measured to lengths of more than 100 μ (0.1 mm.); with waves hundreds and thousands of millimetres in length we pass into the range of electric radiation; radiotelegraphy makes use of waves kilometres in length.

When the temperature of the source of radiation is raised, the energy of the radiation, which in sunlight has its maximum at 0.46 μ, is more and more concentrated in the rays of shorter wave-lengths and higher frequencies, and it seems natural that those radiations, the ultra-violet rays and X-rays, should be more injurious to the eye than the longer visible rays. Yet the analogy of alternating electric

currents would not support that argument; high-frequency currents can be borne at tensions which would be fatal with low-frequency currents and continuous currents. If the eye consisted merely of the lens—which bears its name crystalline lens with some justification—one might further expect that wave-length and frequency would, from the safety point of view, make little difference. But our eye is built up of exceedingly complex and delicate organs, which light affects in different, little-understood ways. When lecturing last summer before the Optical Society on "Light Filters for Eye Protection," Mr. L. C. Martin, B.Sc., of the Imperial College of Science, drew attention in this connection to the experiments which Dr. E. K. Martin made on the eyes of freshly-killed rabbits. Such experiments are based upon the assumption that radiations which are not absorbed by an organ are incapable of harming that organ, an assumption which is probably correct in principle, but may be vitiated in practice by the fact that exact quantitative absorption tests are hardly possible. Studying the effects of the ultra-violet rays from an iron arc and a quartz spectrograph on rabbits' eyes, Dr. Martin found that the cornea was fairly transparent, but stopped rays shorter than 0.295 μ completely; that the lens began to absorb at 0.38 μ, and absorbed completely at 0.35 μ; and that the vitreous humour (in a layer $\frac{1}{16}$ in. thick) seemed transparent to short waves, but had an absorption based between 0.28 μ and 0.25 μ. Exposure of the eyes of living animals to ultra-violet rays (from mercury arcs) caused corneal opacity if of sufficient intensity and duration. As now the solar spectrum stops at about 0.29 μ, ordinary daylight should be incapable of harming the cornea, which covers the whole front of the eye. We all know that we should not stare into the sun; the blue light from the sky is not injurious, but the scattered daylight of a haze and that reflected by water and foliage may contain all the original solar radiations. The eye organs mentioned, moreover, act as a lens system, concentrating the light on certain small areas of the retina, which is exceedingly sensitive.

The action of infra-red rays is less clear. Sir W. Crookes found that the radiations from molten glass consist essentially of long waves and do not contain X-rays. That the workers at glass furnaces and blast furnaces, much exposed to heat radiation, do develop cataracts, seems to be due to infra-red rays. As water absorbs infra-red radiation, it may be presumed that the refracting media of the eye would absorb rays longer than 1 μ. Whether the injurious effects produced are merely the results of a rise of temperature, consequent upon absorption within the eye, effects which the hot, dry atmosphere and risk of draughts near furnaces would accentuate, or whether the infra-red rays have effects of their own, is not understood; but the protection of the eye has to guard against infra-red as well as against ultra-violet rays. There are other things which irritate and fatigue the eye: unsteady, flickering illumination; sharp contrasts of light and darkness and of objects in different colours, to which the eye, which is not achromatic, cannot adapt itself; bad definition of images or glare produced by microscopes and telescopes; an atmosphere impure with dust and vapours—light filters cannot meet all these troubles.

The eye protection which spectacles can afford is necessarily imperfect lest the spectacles, like the gas masks, become a nuisance which the worker rather dispenses with. Up till recent years light filters were essentially smoky glasses or cobalt glasses, intended to stop either the glare or the ultra-violet. The former object was generally realised, with the result that the wearer of the spectacles complained about insufficient light. The ideal light filter would stop all injurious radiations without much diminishing the general brightness. In testing light filters from this point of view Mr. L. C. Martin made use of three apparatus: that of Messrs. Hilger (a quartz spectograph for ultra-violet light, in which the original beam and a beam sent through the specimen are compared, rotating sectors being interposed for varying the exposure); the apparatus of Sir William Abney for examining the visible spectrum; and the apparatus of Professor H. L. Callendar for the infra-red. Mr. Martin's apparatus were not well suited for determining the absorption at either end of the visible spectrum, especially near 0.76 μ in the infra-red, and the measurements in these regions might be wrong by 2 per cent. or 3 per cent., whilst the other measurements were probably correct within 1 per cent. The glasses which he examined were always plane and well polished, about 2 mm. in thickness generally, but varying much in thickness; the results were calculated for a thickness of 2 mm. The glasses tested were: neutral glasses, *i.e.*, glasses of a grey smoke tint; various glasses of Sir William Crookes, who four years ago presented a paper on these researches, which he is still continuing, to the Royal Society; fieuzal glasses, the greenish-yellow tint of which is probably due to chromium; Hallauer glasses, of a greenish smoke tint; signal green, red and yellow glasses. Some dyed celluloid and gelatine films were also tested.

Mr. Martin gives his results chiefly in tabular form and in transmission curves for the different regions of the spectrum without much general summary. The time for generalisation has hardly come, in fact. The ideal spectacles which will keep out the glare of the sun, arc and snow, and which will protect the man in front of the furnace as well as the experimenter with ultra-violet rays, is not likely to be discovered, apparently; absorption at both ends of the spectrum and transparency in the visible region are difficult to combine. Neutral glasses which contain various metallic oxides Mr. Martin found to be ineffective in both extremes, especially in the infra-red, unless too opaque generally. The Crookes glasses are made by Messrs. Chance and other firms; Sir William has no commercial interest in them. The several hundred glasses he has studied are all soda glasses, containing some lime, up to 25 per cent. of ceria—which gives a colourless glass if pure, but is not quite free from didymium generally, which introduces a faint reddish tint—and further, the oxides of the ferro-metals (Fe, Ni, Co, Cr, also uranium). What Mr. Martin calls the "Crookes spectacle" glass is presumably his glass No. 185, of an almost colourless tint, faintly grey, in thick layers orange, which Mr. Martin found to absorb rays shorter than 0.36 μ and to transmit 85 per cent. of the visible and 65 per cent. of the infra-red, especially beyond 2 μ. It appears to be a very good glass for general use, and has already become popular. Some fieuzal and Hallauer glasses would rank next to this glass, though they did not appear so effective in the infra-red. Both these styles are made in different grades. The Crookes glass No. 202 (neutral tint, 5 per cent. ferric iron, a little cobalt) had a very strong absorption near 1.3 μ and in the further infra-red, but did not transmit more than 27 per cent. of the visible spectrum. The Crookes glass 246 (tint sage-green, containing 10 per cent. of ferrous oxalate and a little charcoal and red tartar) transmitted only 20 per cent. and 7 per cent. respectively of the visible and infra-red rays and little ultra-violet, and proved most efficient for heat-ray absorption. Signal-green glasses (containing cupric oxide) resembled the glass 202; they had a strong absorption near 1 μ, which rays are prominent in the sunlight. Most of the various celluloid and gelatine films examined, some of which were collodion-coated, transmitted less than 10 per cent. of the visible spectrum, though their organic dyes also absorbed ultra-violet and infra-red rays.

Some of these delicate films require protection for themselves. That applies likewise to thin laminæ of biotite (a smoky-brown mica) and other minerals, and to the metallic films of gold and silver produced (by chemical reduction or by kathode volatilisation) on glass. Silver films, in particular, make excellent filters for heat rays, and there is, on the whole, no longer any lack of suitable light filters for special purposes, though the ideal light filter for general purposes may not yet have been found. That, after all, is not a serious drawback. We always want special clothing and special tools for special work, and what is never grudged in sport should not be grudged in industrial pursuits.

THE ALLGEMEINE ELEKTRICITATS GESELLSCHAFT.—This company states that on July 1, 1917, there were 79,293 persons employed; the proceeds for 1916–17 are not under those for 1915–16, and the prospects for the current year are quite satisfactory.

NOTES.

DEMAGNETISATION OF IRON.

As the magnetic state of a piece of iron does not depend merely upon the field intensity to which the iron is being subjected, but also upon the previous magnetic history of the iron, it is necessary to destroy the effects of previous magnetisation before proceeding to magnetic tests. The destruction is generally effected by the method of reversals, the magnetising current being reversed many times while its intensity is gradually being decreased to zero. The demagnetisation thus obtained is frequently very incomplete, and in the case of an iron ring, which is a closed magnetic circuit, there would in such an instance be no external evidence of the remnant magnetism. Studying the measurement of magnetic induction and magnetic permeability recently in the University of Michigan, Mr. A. Whitmore Smith (*Physical Review*, May and September, 1917) observed a very considerable time lag in the rise of the induction from the outside surface to the centre of a bar which is being magnetised by a current sent through the solenoid surrounding the bar. Owing to the eddy currents which circulate in the iron in a direction opposite to that of the magnetising current, the magnetic flux does not reach its full value until several seconds after the reversal of the magnetising current. If, then, the magnetising or the demagnetising currents be reversed at too rapid a rate, there will be little effect upon a considerable portion of the interior of the iron. This consideration suggests demagnetisation by current reversals at slow rates, and in his last paper on the demagnetisation of iron Smith attempts to answer two questions: in what state will a given process of demagnetisation leave the iron? and in what manner will the B–H curve or the μ–H curve be affected by the method used for the previous demagnetisation? Four different methods of demagnetisation were tried. In the first method an iron ring, previously magnetised by a continuous current of 1.5 ampere, was subjected to an alternating current of 60 cycles, the intensity of which was slowly reduced from 1.5 ampere to 0.02 ampere; the hysteresis curve afterwards taken showed that three-fourths of the residual magnetisation was not removed by this treatment. Better results were obtained with stronger alternating currents of 16 amperes, and also when the reduction in the intensity was effected by withdrawing a copper wire from a liquid rheostat containing a plate electrode; in this case the alternating current would be partially rectified. In the second method demagnetisation was tried simply by slowly reducing the magnetic field (continuous currents) to zero without any reversal; there was almost the same very imperfect demagnetisation as in the first case. In the third method the continuous demagnetising current was diminished and reversed by hand, with the aid of a mercury commutator, at the rate of one cycle per second; two-thirds of the magnetisation were then left in the iron ring. All this was to be expected after the experiments on the serious time lag. Reversals were then made once every 10 seconds while the current intensity was reduced to zero in 12 steps, there being 10 reversals in each step. In this case the demagnetisation was almost complete, the hysteresis curve being reduced to a very small loop about the origin. In the fourth method the current was reversed fewer times, but the intervals between the steps of the current reduction were made longer. The general conclusion drawn is that one reversal per second may be too rapid for demagnetisation. The time required for the full reversal of the magnetic flux should be determined in each instance. This is done by closing the galvanometer key after reversing the magnetising current and by noting the interval of t seconds, necessary in order that there should be no deflection; the reversal of the demagnetising current should then not be faster than once in $2t$ seconds. The t, it should be noted, is not constant for the same ring, being longer for regions of greater permeability.

RAPID NICKEL-PLATING.

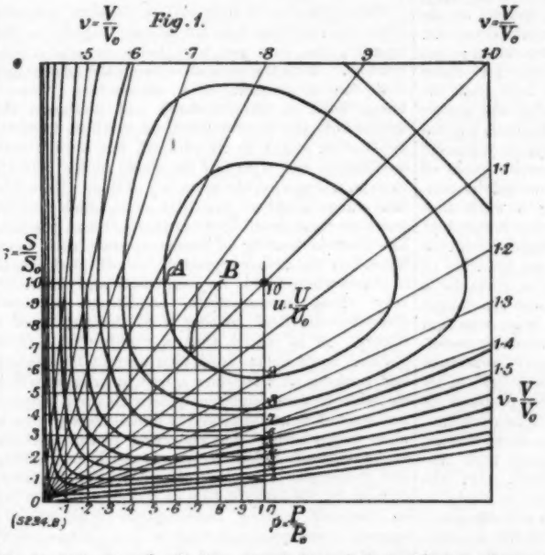
Two years ago we commented on the remarkable results which Dr. Kalmus and his colleagues, studying the possibilities of cobalt on behalf of the

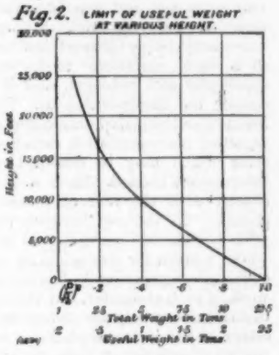
Canadian Government, had obtained with cobalt-plating baths. (See ENGINEERING, October 29, 1915, page 452.) This success has speeded-up the nickel-platers in America, and at the Washington meeting of the American Electrochemical Society (see vol. 29 of the Transactions of this Society) two communications on nickel-plating were discussed. In the first, Messrs. F. C. Mathers, E. H. Stuart and E. G. Sturtevant described experiments made in the laboratory of the University of Indiana. They recommend that the purest anodes of nickel should be used; there is a belief among nickel-platers that pure nickel anodes will not dissolve well, and they found indeed that strips of nickel cathodes of a purity of 99.8 per cent. would not regularly dissolve as anodes. Yet such anodes have the great advantage that they do not introduce any impurities into the bath, whilst the common impurity, iron, discoloured the deposits and caused the formation of a sludge. By adding a chloride, of nickel or magnesium, to the bath they improved the dissolution of the anode. The anode should be completely immersed, and to keep any solid impurity away from the cathode, where it would cause what they called pitting—hardly the correct term—the anode should be suspended in a bag. The solution should be stirred if perfectly clear, but be kept at rest for eight hours or more before use if turbid with solid particles. The greater the ratio of nickel sulphate to nickel-ammonium sulphate, the brighter the deposits they observed. Their best bath consisted of 4 per cent. of nickel-ammonium sulphate, 10 per cent. to 14 per cent. of nickel sulphate, 1 per cent. to 3 per cent. of boric acid, and 0.2 per cent. to 0.3 per cent. of ammonium citrate; the citrate tends to keep the bath clear, and the boric acid helps to maintain the slight acidity which is desirable. The current density recommended is 1.6 ampere per square decimetre (15 amperes per square foot), which would deposit a layer of 0.0025 cm. thickness in 1¼ hours. Dr. O. P. Watts, of the University of Wisconsin, the author of the second paper, does not make use of the very generally applied double sulphate of ammonium and nickel. His preferential bath consisted of 240 grammes of $NiSO_4.7H_2O$, 20 grammes of $NiCl_2.6H_2O$, and 20 grammes of H_3BO_3 (boric acid) per litre of water. The nickel chloride might be replaced by magnesium or also by sodium chloride; by heating this bath up to 70 deg. C. the rate of depositing could be increased more than twofold, and at current densities of 22 amperes to 33 amperes per square decimetre (200 amperes to 300 amperes per square foot) he claimed to accomplish in 10 minutes what ordinary rapid plating did in one hour; these high rates were only realisable with nickel chloride baths. The advisability of working at such high current densities was questioned by Mr. Addicks, who was in the chair. Mr. G. B. Hogaboom stated, however, that such rates were actually used at Wichita in the lamp works; but it was necessary to rotate the cathode at 1,000 r.p.m., and he admitted that the rapid deposits obtained at high temperatures were not quite white, but rather yellow, which created a prejudice. Anodes of nickel shot (granules), never quite free from iron, could be used, he remarked, but in that case ammonium salts had to be absent, because they would lead to coatings of iron hydrate forming round the granules, which interfered with their dissolution. Mr. Hogaboom himself presented a communication on "Some Unsolved Problems of the Electroplater," in which he put twenty-four definite questions; this paper was followed by an instructive discussion. We might mention that doubts were expressed as to the claimed superiority of the cobalt bath; electro-plating is an art, however, in which much depends upon the strict observance of the rules and on apparently insignificant factors.

THE LATE MR. JOHN COCHRANE.—We regret to have to announce the death, which occurred at a nursing home in Glasgow, on Monday, October 22, of Mr. John Cochrane, who, in partnership with his brothers, owned the Grahamston Foundry, which had been established many years ago at Barrhead by their late father. Mr. John Cochrane was formerly provost of Barrhead, and also served for some time on the parish council and school board. He was chairman of the Mission Coast Home, Salcoats, and a Justice of the Peace for the county of Renfrew. He was of a most sympathetic nature and will be missed by a wide circle of friends.

AEROPLANE LIMITS.

IT is a commonplace of bridge engineering that there is a fixed limit to the length of span possible with a given type, since the weight of the structure goes up rapidly as the span is increased, and at some limit of span becomes so large that the bridge would break down under its own deadweight acting alone, even without the added burden of the traffic to be accommodated. The limiting useful span is that at which the stresses due to the weight of the structure plus that of the traffic reach the safe limit, and an increase of span beyond this is impracticable without a change either in the type of bridge or in the materials with which it is made. The supporting surfaces of an aeroplane are subject to the same law—that their weight increases with increase of dimensions more rapidly than their strength does, and this would in itself suffice to fix a limit to the possible size of aeroplanes. Matters are, however, still worse when allowance is made for the fact that level flight is impossible without engine power, and hence, before the wings can carry any useful load whatever they must be able to support not only their own weight and that of their essential structural elements and connections, but also that of the engine. It is thus only the balance of sustentation left after deduction for these that is available for supporting the useful load, which will include the weight of the crew and of all other weights which are not in the shape of fixtures or engine supplies.





In a recent issue of *The Aeronautical Journal* Lieutenant A. R. Low, R.N.A.S., has given some interesting curves showing how the useful load in any machine will vary if the conditions differ in any way from the optimum. In a paper read before the Junior Institution of Engineers in April, 1913, he established rational relationships between the useful load carried and the engine weights, the structural weights, and the coefficients of sustentation and of resistance, and from these he has now plotted the curves reproduced in Fig. 1. These curves are applicable to any and every aeroplane, and show at sight how with a given type the performance will vary with changes in the engine power, wing surface and speed. For every type there is, in fact, some one combination of power surface and speed which is most effective, as estimated by the useful load carried. Thus let P_0 denote the power expended under these conditions, and S_0 the corresponding wing surface, whilst V_0 denotes the speed, then if U_0 be the useful load then carried, the relation between these various quantities at any other load is deducible from the curves plotted in Fig. 1. The isolated central point of the diagram represents the conditions corresponding to the maximum possible load. This can be carried only at one speed and with one power. If the power be increased beyond this value the consequent increase in engine weights will diminish the possible useful load carried. These useful loads are plotted as contour lines, of which that corresponding to the optimum conditions is represented by the central point of the diagram, whilst other loadings are represented by the numbered curves. The lines shown as radiating from the lower left-hand corner of the diagram correspond to different speeds. The central ray, lettered as $v = 1$, represents the speed at which, under optimum conditions as to power and wing surface, the maximum useful load is carried. A and B are points on the contour corresponding to a useful load equal to nine-tenths of the optimum. If the wing surface be the same as in the best conditions, then this useful load of nine-tenths will be carried with an expenditure of only about 0.56 of the power required at the maximum useful effect, and this reduction of the power by 0.44 will reduce the speed by about 0.18 only. The reduction of power is shown by the point where the contour 0.9 cuts at A the horizontal line through the centre of the figure. By reducing the surface to about two-thirds of its optimum value, this same load of nine-tenths of the maximum can be transported at the same speed of the machine as in the optimum conditions with an expenditure of about two-thirds of the power required to carry the maximum load. This is indicated by the point B, where the contour 0·9 cuts the ray $v = 1$. Similar conclusions follow when the useful load is still further reduced, as is clearly shown by the corresponding contour lines. In general, aeroplane practice lies wholly within the lower left-hand quarter of the complete diagram. In some cases, however, it has been found desirable, for certain purposes, to go outside these limits, which is accomplished by reducing the fuel and oil supplies carried. The useful load can in that case be increased, but the length of flight possible is, of course, diminished. The curve shown in Fig. 2 represents, Lieutenant Low states, about the maximum useful loads with which flight is now possible at the different levels indicated, though there are indications that improvements in materials and in the design of details may ere long yield results better than those represented by the curve. The numerical results merely represent the machine ideally possible on the basis of the data of 1912, and though the limits indicated by the curve have only now been reached after five years of exceptionally rapid progress, they must not be taken as final. Every reduction in engine and structural weights obtained by better design or by cutting factors of safety puts up the value of the useful weight carried nearly as the square of the value of the improvement. The curve has been plotted on the basis that the fuel tanks are full, carrying the normal supply of petrol. The heights shown are the "ceiling" heights of the machines with different weights on board. As a machine rises, the density of the air diminishes and its sustaining power falls off. The ceiling height of a machine is the limit to which it is possible for the machine to climb. At this limit the machine can just fly horizontally when developing its maximum engine power. If an attempt be made to rise above this "ceiling"

height by increasing the angle of attack, the speed falls off because the head resistances are increased, and the engine revolutions and horse-power diminish accordingly, with the result that the machine begins to come down. If, on the other hand, the angle of attack is diminished, the speed will rise and the engine power go up, but the angle of attack is then too small to sustain the weight, and the machine descends, as in the previous case. The limit of useful load varies approximately as the cube of the density of the air, which diminishes rapidly as the height increases. The abscissæ $\left(\frac{\rho}{\rho_0}\right)^3$ denote the relative densities at different heights.

LITERATURE.

Electrical Engineering Practice. A Practical Treatise for Civil, Mechanical and Electrical Engineers, with many Tables and Illustrations. By J. W. Meares, F.R.A.S., Electrical Adviser to the Government of India, assisted by R. E. Neale, B.Sc., A.C.G.I. Third edition, revised and enlarged. London: E. and F. N. Spon. [Price 25*s.* net.]

This is an enlarged edition of a work that appeared two years ago and was favourably noticed at the time in our columns. Enlargement does not necessarily imply proportional improvement; but in a more ambitious work we look for closer continuity and cohesion, and it is here that the author has disappointed us. Possibly the author has not contemplated uninterrupted perusal, but has regarded his compilation rather as an encyclopedia from which may be drawn the precise piece of information needed. Such a view would be consistent with the aim of producing a work that should "fill the gap between the many excellent pocket-books of bare data and the highly technical works written for specialists in various branches of electrical engineering." There may be room for a work of such character, but there is also the danger of failing to satisfy the demands of those who find either of these classes of books occasionally useful. We can understand that the country gentleman who is contemplating installing electric light in his house, or the man of business who proposes to substitute electric traction for horse-drawn vehicles, will find in this volume much pithy, acute advice, accompanied by estimates that, used with discretion, cannot but prove serviceable. On the other hand, the trained engineer who is likely to be consulted on the installation of a suitable plant for supplying electric light in mines or the development of a scheme of hydro-electric energy would hardly be assisted by the somewhat scanty information supplied. Similarly, the expert mechanic who might wish to set up, by permission of the Postmaster-General, a simple installation of wireless telegraphic communication, or to construct his own telephone, will equally find little to guide him.

The plan of tripartite division adopted in previous editions has been preserved. The first section is devoted to definitions, elementary explanations of electric terms, and descriptions of varied systems of electric supply. It is difficult, perhaps impossible, to breathe interest into a succession of definitions. They are necessarily fragmentary and disconnected; inducing a great strain on the memory, and many may wish that the information could have been imparted in a more palatable manner or embodied in the more practical part of the book, each term being explained as it was needed. The author complains that a difficulty is experienced in explaining such terms as "pounds-feet" and "feet per second per second." We can well believe it, if the student has had no preliminary training, but, if not sadly overlooked, we do rot find any attempt to remove the admitted difficulty, though such an opportunity occurs when dealing with power and work.

We are glad to pass to the second division, on "Installations in Buildings and Roads," for here the author is seen at his best. His advice is sound and practical, as his experience is rich and varied. He has that to say by which the public could profit with very little effort to themselves. This is particularly the case in the elementary information supplied in the chapter on light and illumination. Much disappointment would be saved and greater intelligence would be exhibited in the methods of artificial lighting if less attention were given to the intensity at the source and more to the plan of distribution. We are not referring to those luxuries at the command of the wealthy, where shadowless and uniform illumination is obtained and the source of illumination made unobtrusive. The long purse may succeed in combining harmonious groups of mercury and neon lamps that please the artistic eye; ingenuity can twist the Geissler tube into an endless variety of delightful designs that minister to comfort or pleasure; but where economy in first cost and recurring charges have to be considered, a few lamps of great intensity are preferred and loss of light by shades is disapproved. Comfort is disregarded, and health is liable to suffer. Every attempt that is made to insist on discretion in the arrangement of lamps and bring about the necessity of adequate distribution is to be welcomed. The more frequent use of gas-filled "half-watt" tungsten lamps, adapted to existing arc circuits, makes wider information the more imperative, for without suitable fittings to prevent glare the intensely brilliant filaments are a source of danger.

The application of electricity to domestic purposes other than lighting does not advance rapidly in this country, the cost per unit being generally prohibitive. With the view of securing the advantages that the attainment of a satisfactory "load" brings both to the consumer and producer, the author indicates several directions in which domestic application might be encouraged, but always with moderation and with fair balancing of the benefits to be gained against the necessary outlay. Of electric fans and punkahs we have little need—such contrivances are reminiscent of the author's Indian practice. The electric heating of rooms appeals with more force, but the author regretfully admits that except in places where fuel is very expensive and electricity very cheap—incompatible conditions in most districts—electrical heating is of the nature of a luxury. It is stated that a number of central stations contemplate supplying current for heating and cooking at a farthing a unit, a price at which electrical heating might compete with stove heating, but most of us would probably find ourselves outside those happy areas. The charming picture that the author spreads before us of increased convenience and cleanliness is most alluring, the nice regulation of heat by the introduction of a thermostatic relay to suspend current consumption automatically appeals to our economic sense as in accordance with the fitness of things, but the bill of costs at the end has a sobering and depressing effect. Mr. Meares makes no attempt to conceal the fact that a pennyworth of coal or gas contains far more thermal energy than a pennyworth of electricity though he also makes it clear that a pennyworth of convenience may be worth a penny. If the delusions of hope tempt us to overcome the restraint imposed by discretion, the author is not to blame. He is ever ready with estimates, calculated on a fairly generous scale, for he evidently likes good work, and is prepared to recommend it. This tendency is particularly manifest in the chapters on wiring methods. He is fully aware of the risks that may arise from careless workmanship, and his cautions deserve to be treated with respect. In his remarks on electric shock, fusible cut-outs and such-like devices he is evidently writing for those who possess little knowledge and are apt to underrate the risks electric service entails. With the increasing use of alternating currents at high voltage, we could wish that his weighty words may reach a wide public.

The third section, devoted to electric plant and supply, is the longest of the three divisions, but would need to be much extended if it dealt exhaustively with the large number of topics mentioned. Undoubtedly much of the information will prove useful, but there can be little advantage in introducing subjects—as, for example, alternating-current commutator motors—simply to say that the subject is one for the specialist, or to refer the reader to other sources for description. It is this uneven and fragmentary character that strikes one as unsatisfactory. Some of the descriptions of methods and of instruments will hardly be intelligible to the class of readers addressed in the earlier chapters. Such subjects as water-power plant and the development of high heads do not immediately concern the electrician, while the employment of electricity in mines is not one for the inexperienced to trifle with. On the other hand, the chapters on electric traction and electric automobiles are more elementary in character, and notwithstanding somewhat desultory methods of description, show the hand of the master and should prove edifying.

The book is well indexed, and the illustrations, if not numerous, are clear and purposeful. There is one, however, on page 340, intended to demonstrate the correct method of reading consecutive dials, in which the position of the hand, not according with the text description, may create some confusion, but such oversights are rare. The plan of giving paragraph numbers at the head and current page numbers at the foot is much to be commended.

BOOKS RECEIVED.

The Founder's Manual. By David W. Payne. New York: D. Van Nostrand Company; London: Crosby Lockwood and Co.

Mechanical Equipment of Buildings; a Reference Book for Engineers and Architects. By Louis Allen Harding and Arthur Cutts Willard. Vol. I. *Heating and Ventilation.* New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18*s.* 6*d.* net.]

The Design and Construction of Industrial Buildings. By Moritz Kahn. London: Technical Journals, Limited, 27 and 29, Tothill-street, S.W. 1. [Price 7*s.* 6*d.* net.]

The Motor, Marine and Aircraft Red Book, 1917. Compiled by W. C. Bersey and A. Dorey. London: The Technical Publishing Company, Limited. [Price 7*s.* 6*d.* net.]

C.M.U.A. Handbook of Approved Depots. Compiled for the C.M.U.A. by Frederick G. Bristow, F.C.I.S. London: The Commercial Motor Users' Association. [Price 1*s.* 6*d.* net.]

Reid's Handy Colliery Guide and Directory for the Counties of Northumberland, Durham and Yorkshire. Newcastle-on-Tyne: Andrew Reid and Company, Limited. [Price 2*s.* 6*d.*]

Proceedings of the Incorporated Municipal Electrical Association, 1917. London: Wyman and Sons, Limited. [Price 5*s.*]

Diesel Engine Design. By E. Mortimer Rose. Manchester and London: Emmott and Co., Limited. [Price 5*s.* net.]

Street Railway Fares, their Relation to Length of Haul and Cost of Service. By Dugald C. Jackson and David J. McGrath. London: Hill Publishing Company. [Price 10*s.* 6*d.* net.]

Operation and Maintenance of Irrigation Systems. By S. T. Harding. London: Hill Publishing Company. [Price 10*s.* 6*d.* net.]

Great Western Railway Mechanics' Institution, Swindon. Descriptive Catalogue of the Books in the Lending and Reference Departments of the Library, 1917. Compiled by W. H. Baguley, F.L.A., Librarian. Swindon: Morris Brothers. [Price 1*s.* 6*d.* net.)

Charing Cross to Bagdad. A Great Inter-Allied Reconstruction Scheme. London: Published by *The Daily Chronicle.* [Price 5*s.* net.]

Hawkins' Electrical Guide. Questions, Answers and Illustrations. No. 4. *A.C. Switch Boards, Circuit Breakers, Measuring Instruments.* No. 6. *Alternating Currents and Alternators.* By Hawkins and Staff. New York: Theo. Audel and Co.; New Brighton: Cheshire: Edwin A. Mansfield and Co. [Price 5*s.* each part.]

Parallel Tables of Slopes and Rises. By Constantine K. Smoley. London: Hill Book Company, Limited. [Price 17*s.*]

Useful Engineers' Constants for the Slide Rule and How they are Obtained. Glasgow: J. A. Burns. [Price 1*s.* net.]

Canada Department of Mines. Bulletin No. 15. *The Mining of Thin Coal Seams as Applied to the Eastern Coalfields of Canada.* By J. F. Kellock Brown. Ottawa: Government Printing Office.

The Composition of Technical Papers. By Homer Andrew Watt. London: Hill Publishing Company, Limited. [Price 6*s.* 3*d.*]

Copper Amalgam as Metal Cement.—The Vienna metal cement, which is sometimes mentioned in descriptions of apparatus, is a copper amalgam. To prepare this amalgam the *Giesserei Zeitung* of July 15, 1917, recommends to place a strip of zinc into a solution of copper sulphate, to bring the powdery copper which is precipitated into a mortar, and to knead it with mercurous nitrate, mercury and water into a plastic paste; three parts of copper are needed for seven parts of mercury. When metals are to be cemented with this amalgam, which is brought on the market in small cylinders, the parts are polished and heated up; the amalgam itself is heated to 80 deg. or 90 deg. C., and the parts are then pressed together. The amalgam itself can be hammered, rolled and put under a die; it takes a good polish. Placed in boiling water it softens sufficiently to use it as a material for taking casts. It is rolled into a thin strip, which is applied to the heated object; the replica obtained is afterwards backed with type metal.

INDUSTRIAL NOTES.

The Textile Industry Central Advisory Committee (Operatives), which has recently been appointed to advise and assist the Ministry of Labour upon matters arising in the administration of the Employment Exchanges which affect workpeople in that industry, held their fourth meeting on Thursday, October 25.

The committee discussed further the regulations as to the signing of the unemployment register or vacant book. They also considered the lines upon which should be instituted joint trade advisory committees for the various branches of the textile trades, to advise and assist the Ministry of Labour and the Ministry of Pensions upon the methods and conditions of training disabled sailors and soldiers. It was agreed that this question should be taken up with the employers' committee, as soon as that body meets.

The Government has approved the formation of a Flax Control Board, with the following terms of reference :—

To supervise and co-ordinate the arrangements for securing supplies of seed, flax and flax goods for war purposes and to take such steps as will satisfy the board that, after meeting requirements for aeroplanes, sufficient flax is, so far as possible, available for other war purposes, and to take any further action that the board may consider necessary.

Mr. P. Guedalla will act as secretary to the board, to whom all communications should be addressed at the War Office (Contracts Department), Imperial House, Tothill-street, Westminster, S.W.1.

The question having arisen as to whether Section 3 of the Munitions of War Act, 1917, enables a workman who has undertaken the performance of a definite job to give a week's notice and leave before the completion of the job, the Minister of Munitions announces that he has been advised that the section does not apply to contracts of service for a definite period or for the doing of a particular job, but is confined to contracts which, apart from the Act, are determinable by notice or at pleasure.

The answer is, therefore, that the section does not enable a workman who has undertaken the performance of a definite job to give a week's notice and leave before the performance of the job.

A representative general meeting of the drop-forging and stamping trade was held on Thursday, October 25, at the offices of the Chamber of Commerce, New-street, Birmingham, under the chairmanship of Mr. Alderman A. D. Brooks, J.P., the district organiser of the Federation of British Industries. It was unanimously resolved: "That an Association of Drop Forgers and Stampers be formed in the general interests and for the development of the industry."

The following were elected as an executive committee, with power to add to their number, for the drafting of the objects, &c., of the association :—

Birmingham District: Mr. E. A. Archer, Messrs. Archer Stamping Company, Birmingham; Mr. W. A. Lansdell, Messrs. Deritend Stamping Company, Birmingham.

Black Country: Mr. C. F. H. Treadgold, Messrs. Hughes-Johnson Stampings, Limited, Langley Green; Mr. H. E. Wilson, Messrs. Garrington and Sons, Limited, Darlaston.

Coventry District: Mr. C. A. Clarke, Messrs. Thomas Smith's Stamping Works, Limited, Coventry.

Lincoln District: Mr. Pope, Messrs. Robey and Co., Limited, Lincoln.

North of England: Mr. J. R. Sumner, Messrs. Heavy Stampings, Limited, Middlesbrough.

Scotland: Mr. W. B. Laird, Messrs. Laird and Son, Ayr.

Sheffield: Mr. G. H. Cowman, Messrs. Turton, Platts and Co., Limited, Sheffield.

The notice we have received is signed for and on behalf of the committee by Mr. H. B. T. Wilde, A.C.A., secretary, 45, Newhall-street, Birmingham.

In the discussion as to how the engineer is to benefit by the inevitable change impending in political representation, the technical Press will be a factor, says *The Canadian Engineer*. To the credit of the legal fraternity, they, like the practitioners of medicine, are a close and compact corporation, and are in the possession of means to discipline the recalcitrant. Were the professional engineers consolidated in a similar manner, the chance of their representing the electorate would be enhanced, for there is no engineer but is convinced that he is more or less penalised by his profession in the sense that his interests are not regarded or recognised. The proclamation needed is that the engineer is worthy of widespread public support as a public man representing general national interests. The profession of an engineer is the finest clearing-house for character ever seen. It is character as much as technical ability which makes for success in a professional capacity. If the engineering character can be impressed upon the public by the engineers, through the medium of their Press, radical changes will be effected.

The wage advance in the iron and steel industry announced recently in the case of the American Steel Corporation, to become effective on October 1, is, says *The Iron Age*, New York, the fifth advance of approximately 10 per cent. made since the war started. The four preceding advances became effective on February 1, May 1 and December 15 of last year and on May 1, 1917. The total wage advance in less than 10 years has been about 102 per cent.

According to *The London and China Telegraph*, Japan is now having to wrestle with industrial problems which have for a generation past exercised the minds of statesmen of Western countries. The relations between capital and labour have been a perennial source of trouble in this country and on the European Continent, and now from all accounts it would seem that Japan is going through the same experiences. During the present year strikes have become of frequent occurrence, so much so that the Press is calling upon the Government authorities and the capitalists to pay closer attention to the question. According to the latest statistics compiled by the Home Department, already over 180 strikes have been recorded since January this year. This is a remarkable increase when compared with the 70 or 80 strikes in 1915, and the 100 or so in 1916. In all branches of industry the tendency to strike is observable, and in many cases the men have adopted a very firm attitude. Their organisation, of course, is not so complete as that of their Western confrères, but that is only a question of time. The matter, of course, is one entirely for the Japanese people to settle, and it will be interesting for outsiders to observe how the Government will deal with the difficulty. In the West it has not been found an easy problem to solve, and neither, we imagine, will it be in Japan.

To meet the urgent need for increased output of aircraft, the Minister of Munitions recently appointed a representative committee to consider the whole position of aircraft woodworkers as to rates of wages and working conditions. The committee recommended the introduction of systems of payment by results, coupled with the establishment of standard district rates, for skilled woodworkers.

With regard to the latter point, the Minister of Munitions has decided to make an Order fixing the standard rates for skilled woodworkers in each district on the basis of the standard rates of carpenters and joiners, cabinet makers or coachmakers, whichever may be the highest, with a minimum of 1*s.* per hour, as from November 1.

This means that after November 1 the minimum rate for such men in London will be 1*s.* 3*d.* per hour. The new rate will include any war bonus that has been given up to date, but will not prejudice men who already have more favourable terms.

The other main feature of the Order will be the establishment of overtime rules and other working conditions.

In regard to payment by results the Minister has intimated that he will approve and support any satisfactory system that may be introduced by mutual agreement between the employers and workmen in any aircraft establishment.

The following brief abstracts from German journals will be found of interest :—The *Frankfurter Zeitung* of August 10 published a communication from a Silesian correspondent, stating that ten large meetings of miners had taken place, at which resolutions were passed demanding State aid for the improvement of their wages, as the mine owners were not in a position to pay higher rates. The same journal, of August 18, published a communication from Essen to the effect that the four miners' unions had resolved to demand higher rates of pay on the following scale :—Not less than 12 marks (12*s.*) per shift for hewers, exclusive of subsidies for children and other allowances; an increase of 1 mark per shift for all male adult workmen; of 75 pfennig (9*d.*) for adult female workers, and of 50 pfennig (6*d.*) for juveniles; a doubling of all existing subsidies for children.

According to *Vorwärts*, September 4, "The State mines in Ibbenbüren appear to be the very reverse of a model State undertaking. At the proceedings before the Conciliation Committee at Münster, Westphalia, the Workers' Committee pointed out that eighteen-year-old workmen in the mines were receiving in all 1·80 mark (1*s.* 9*d.*) per day. Men who had returned from military service had to be content with wages of from 2·40 marks to 2·60 marks (2*s.* 5*d.* to 2*s.* 7*d.*). The monthly wage of fully skilled hewers, who had been engaged since their youth in mining, only very rarely exceeded the sum of 125 marks (6*l.* 5*s.*). Such wages must, indeed, be the lowest miners' wages in all Germany, and are far inferior to the Silesian famine wages. It is a matter of course that under such conditions output cannot increase."

A correspondent in Upper Silesia wrote to *Vorwärts*, August 18, that efforts were being made by colliery owners again to raise the price of coal, the reason alleged being the increase in working costs, especially in miners' wages and materials. The increase this time was to exceed the usual one of 2 marks (2*s.*) per ton, and was expected to come into force on October 1. (The average earnings per shift in the second quarter of 1917 was, for hewers and trimmers, 7*s.* 8*d.* in Upper Silesia, and 5*s.* 7*d.* in Lower Silesia.)

The *Berliner Tageblatt* for September 19 published the following appeal issued by the War Department :—"Comprehensive measures have been taken to reduce coal consumption to such an extent that the absolutely necessary fuel for industry and domestic purposes may be available. But the voluntary co-operation of the people is essential, as complete results cannot be expected from Government orders alone. Let everyone be convinced that by economy in coal, and in the consumption of its most important products, gas and electricity, he is serving well both the community and himself. Numerous suggestions have been made officially and by the Press to this end. An important means is the greatest possible application of an uninterrupted working day. Unless there is absolute necessity, the interruption of the working day means an increase in the consumption of fuel and light; all employers, therefore, whether manufacturers or merchants, should endeavour to introduce the uninterrupted working day."

According to *Die Zeit*, of August 31, "The growing scarcity of male workers and of labour of all kinds in Vienna, and the continuous increase in the cost of living and decrease in the value of money, have brought about a continued rise in the cost of labour. Only manual labour, however, has participated in this rise in wages, while officials and leading workers generally are very little better paid than in peace time. Among manual workers earning relatively high wages are, first of all, the munition workers. Untrained workers earn up to 70 kronen (58*s.*) per week; trained workers, 90 kronen to 100 kronen (3*l.* 15*s.* to 4*l.* 3*s.*). Those doing special work receive from 100 kronen upwards. In a munition factory in Vienna a family of father, mother and son earned amongst them 75*l.* in one month."

One of the most attractive fields for investigation that are being opened by the exigencies of the war is that which pertains to the winning of tin and tungsten. Recently some successful experiments have been made with a view to increasing the recovery of tin. No systematic researches, however, have been undertaken beyond those designed to improve the appliances now in use; and, having regard to this fact, the Privy Council Committee for Scientific and Industrial Research has expressed the hope that a research association might be established in order that the series of investigations already undertaken might be continued on a larger scale.

One of the difficulties in the way hitherto has been the want of adequate funds for sustained investigation and experimental trials. But the Ministry of Munitions, represented by the Department for the Development of Mineral Resources, is now venturing on a strong effort to make progress possible. It is suggesting that those interested in the tin and tungsten mines of Cornwall and Devon should co-operate in the establishment of a research association and contribute to a central fund devoted to a study of the many-sided aspects of the problem. In this way adequate means might be provided annually for two or three years; and with such a fund, supplemented if necessary by a grant from the Committee of the Privy Council, experimental researches upon scientific principles could be conducted under the continuous supervision of first-class professional men, and upon a basis of cost which individual operators do not feel themselves able to bear.

This proposal is one which should appeal to mining companies and royalty owners from a strictly business standpoint. Under present methods over 35 per cent. of tin and a higher percentage of wolfram in the ore is lost. An improvement of even 10 per cent. in the recovery would have a very important bearing on the fortunes of the mines now being worked, and would, moreover, offer a considerable incentive for the resuscitation of many properties that have been closed down.

A conference for the consideration of the proposals of the Ministry of Munitions will be held at the Hotel Metropole, Whitehall Place, S.W. 1, on Wednesday, the 7th inst.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few particulars, taken from *The Board of Trade Journal*, on Colonial and foreign engineering projects. Further informaiton concerning these can be obtained from the Department of Commercial Intelligence, 73, Basinghall-street, London, E.C. 2

Western Canada.—According to the *Canadian Engineer*, Toronto, of September 13, investigations conducted by the Water Power Branch of the Canadian Department of the Interior have revealed that in the Great Saskatchewan River and its tributaries, which drain the whole of the southern portion of the provinces of Alberta and Saskatchewan, and in the Winnipeg River and other streams flowing into Lake Winnipeg, there is enough water power to create at least 1,172,000 h.p. of hydro-electric energy. In the Athabasca, Peace, Churchill and other large rivers which drain the northerly portion of the three provinces there is, according to the very incomplete data that have been obtained, sufficient water power to create 5,465,000 h.p. of energy. Only 12 plants have as yet actually been established to make use of this large volume of power, and only 109,000 h.p. is actually being utilised, of which 107,000 h.p. is developed by four plants. Two of these plants are on the Winnipeg River, and belong to the Winnipeg Electric Railway and the Municipal Railway respectively, and two are on the Bow River at Kananaskis, 50 miles west of the city of Calgary, where 31,000 h.p. is developed and used mainly in lighting the city, running its street cars and supplying motive power at cheap rates to its industries. There is sufficient water power in the Winnipeg River to produce, eventually, as great a volume of hydro-electric power as is now taken from Niagara Falls, and there is sufficient in the Bow River basin, supplemented by storage capacity, to create 93,000 h.p., all within easy transmission reach of Calgary.

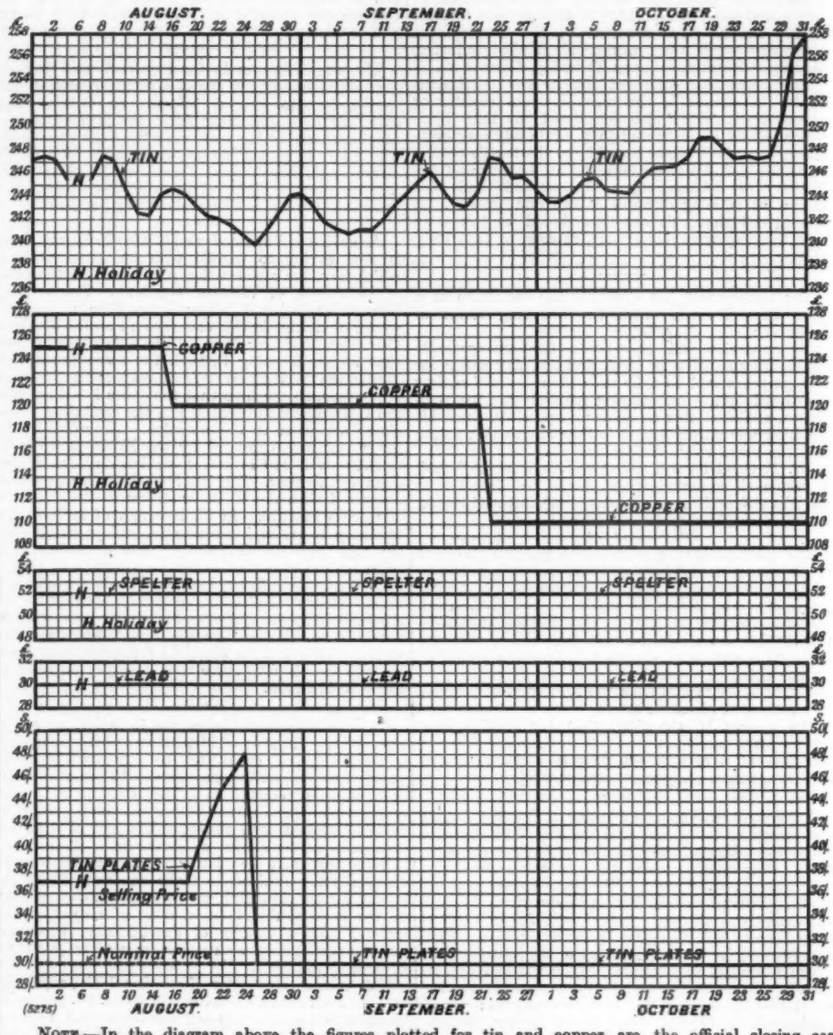
Brazil.—The issues of the *Diario Official*, Rio de Janeiro, of August 21 and 26, contain Decrees approving plans and estimates for railway construction, as follow :—(1) Decree No. 12,603, approving definitive plans submitted by the "Companhia Mogyana de Estradas de Ferro e Navegaçao" for the construction of the first section, 33,280 km. (about 20½ miles) long, of the line from Sao Sebastiao do Paraiso to Passos (Sul Mineira system), at an estimated cost of 2,132,628 milreis. (2) Decree No. 12,623, approving definitive plans submitted by the "Companhia Estrada de Ferro S. Paulo–Rio Grande" for the construction of the section between Tubarao and Cresciuma of the Tubarao–Araranguá Railway. This section covers a distance of 56,550 km. (about 35 miles). The estimated cost of the undertaking is 2,426,682 milreis, excluding the cost of rails, accessories and rolling-stock. [Note.—In reference to the foregoing, regard should be had to the restrictions on exports from the United Kingdom. Milreis = about 1*s.* 1*d.* at current rate of exchange.]

Aeroplane Mail Service.—In Sweden a company has been formed with a capital of 110,000*l.*, to take over some existing works for the purpose of building aeroplanes. In the first place a regular air traffic is to be established between Sweden and Finland, by way of two routes—Norrtelje-Mariehamn-Abo and Norrtelje-Hangö-Abo—the aeroplanes will have double motors, and be capable of carrying six passengers. A Gothenburg-England and a Gothenburg-Sassnitz route are also planned, and the Swedish Government seems to view the scheme with favour.

Critical Points of Air.—The three independent determinations of the critical phenomena of air made by Olszewski, Wróblewski and Witkowski were not quite in satisfactory agreement, probably because air is a mixture and not a homogeneous gas. Redetermining these constants J. P. Kuenen and A. L. Clark, of Leiden (Proceedings Amerstam Akad. Wetenschapen, 1917, pages 1088 to 1098) experienced great difficulties, because a mixture cannot be cooled down as a whole, at least not when the volume is to be changed gradually, as in their experiments. For one thing, in working at low temperatures a certain mass of gas cannot be sealed up in a glass tube by the aid of a small thread of mercury, as in ordinary experiments with gases. During the condensation and evaporation the compositions of the liquid and of the vapour change, and a distinction has to be made, as Kuenen noticed already in 1892 between the "critical plait-point," at which the two co-existing phases become identical and the critical phenomena are most pronounced, and the "critical point of contact," the limit for the separation into two phases. In the interval between the two critical points the condensation is "retrograde," and this retrograde condensation is utilised. With ordinary condensation the liquid phase is steadily increasing as the compression advances; with retrograde condensation, characteristic of mixtures, the liquid first increases to a maximum, and then decreases, and the meniscus between the two phases disappears. This retrograde condensation takes place in the temperature interval between the two critical points. This interval was found to be very small, only 0.1 deg. C., the plait-point of air being at —140.73 deg. C. and 37.25 atmospheres, and the point of contact at — 140.63 deg. and 37.17 atmospheres. The critical densities at the two points were 0.35 and 0.31; the critical density of oxygen being 0.43, that of nitrogen 0.31, the law of mixtures would give a critical air density of 0.34. A blue opalescence was noticed when the pressure was slightly lower than that needed to cause a cloudy condensation; this opalescence disappeared on rapid stirring, which had to be applied to keep the mixture homogeneous. This was one of the great difficulties.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS

(Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



Note.—In the diagram above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

The late Mr. George Thomas Holloway.—We regret to have to record the death, which occurred on Wednesday, October 24, of Mr. George Thomas Holloway, of 13, Emmett-street, Limehouse. Mr. Holloway was chairman of the Royal Ontario Nickel Commission, which was formed in September, 1915, with a view to inquire into the resources, industries and capacity of Ontario with reference to nickel. He graduated at the Royal School of Mines in 1886, and had established a practice in London as a consulting metallurgist and assayer. Mr. Holloway was a vice-president of the Institution of Mining and Metallurgy, and was 54 years of age at the time of his death.

The Shipping Boom.—The shipping boom on the Continent continues unabated, in some places even in an exaggerated form, with fancy prices for vessels and shares and the formation of new shipping companies. Thus several companies have been formed in Holland during the last month or two, comprising the Kustvaart Company, in Rotterdam, with a capital of 2,000,000 gulden, and two more Rotterdam concerns. Also in France much activity prevails. In this direction may be mentioned the Compagnie des Chargeurs Coloniaux, Maritime Franco-Atlantique, &c., and several existing companies are increasing their capital, the Générale Transatlantique, for instance, from 39,000,000 francs to 81,000,000 francs; the l'Union Normande, &c.

Society of Glass Technology.—The first meeting of the new session was held on Wednesday, October 17, in the University, Sheffield, the president, Mr. W. F. J. Wood, B.Sc., presiding over a large and representative gathering. After the formal business had been transacted a paper was read by Mr. Robert E. McCauley, of Swissvale, Pennsylvania, U.S.A., entitled "The Use of Semi-Automatic Glass-making Machinery in America." The author opened his paper with a discussion of the difficulties met with in the introduction of machinery in America, and stated how these difficulties were overcome, particular emphasis being laid on the fact that wages in many cases were doubled by the introduction of automatic machines into the glass industry. He next discussed from the historical point of view various types of machines and presses, showing how the most modern, up-to-date machine developed. Different types of press and blow machines for making narrow-mouth bottles were described in detail, and many interesting facts as to their mode of working were brought out. Points of difference between British and American machines were made clear, the advantages of the latter from the standpoint of production in bulk being emphasised. The paper concluded with a description of the use and abuse of machinery in glass houses. A long and interesting discussion ensued, Messrs. Connolly, Foster, Pitt, Simpson, Hood, Crowther and Swann all taking part, whilst Mr. McCauley replied at length.

WORM GEARING.*

By FRANCIS J. BOSTOCK, A.M.I.Mech.E., A.M.I.A.E., Huddersfield.

Introduction.—Until recent years the theory of worm gear, and still less its manufacture, was very little understood; the gears previously in use were generally for the purpose of transmitting "motion" from one member to another, and usually consisted of a worm of large diameter and low lead angle meshing with a cast wheel, the teeth of which had not been machined. The natural result was that low efficiencies were obtained, hence their use was discountenanced by engineers. All this has now changed; its construction has of late years become a science and its manufacture a precision accomplishment, and it will be the endeavour of the author to indicate some of the factors which have enabled this to be accomplished.

It is not the author's intention to discuss the Hindley or globoidal type, because for general purposes it does not, to his mind, represent such a sound manufacturing proposition as the parallel type, to which the following remarks upon design and manufacture will apply.

Theoretical Considerations.—Before proceeding with the practical part, however, it will be well for one to become acquainted with the terms used, their relations and the theoretical conditions which have to be fulfilled in order to obtain successful gears.

The ratio, as in all other forms of gearing, is dependent directly upon the number of teeth or threads. The distance from one tooth to the next, measured along the pitch line, is called the pitch, and when measured along a line parallel to the axis it is called the linear pitch. The normal pitch is that when it is measured normal to the thread, whilst the circular pitch is measured circularly at right angles to the axis. It will be observed that the circular pitch of the wheel is equal to the linear pitch of the corresponding worm.

The distance travelled, parallel to the axis, by a thread when making one revolution round the worm is called the lead; obviously it is the product of the number of threads and the pitch. As the thread or helix travels round and along the worm it naturally makes an angle to the axis, or to a line parallel to it; this angle is called the spiral angle, and its complement the lead angle. Trigonometry easily establishes their relations.

There are many factors entering into the design of worm gearing. It is not the author's intention to labour them, but briefly to mention a few all-important points that make up a satisfactory gear.

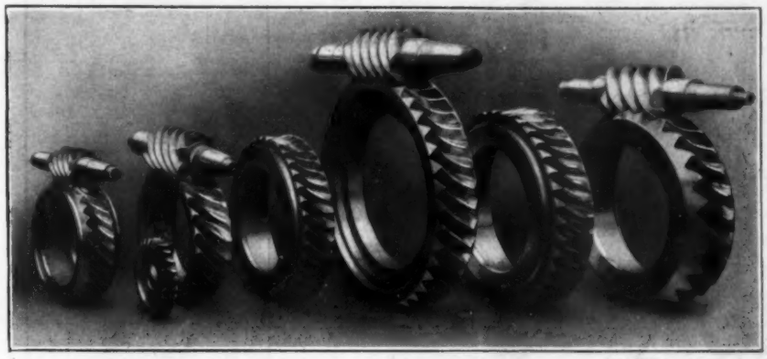


FIG. 1. GROUP OF WORM GEARS.

FIG. 2. LINEAR SECTION OF WORM AND WHEEL.

FIG. 3. NORMAL SECTION OF WORM AND WHEEL.

The lead angle bears an important relation to the efficiency and durability of a worm gear. For many years designers did not realise the importance of having a high lead angle, and the unfortunate experience that many have had has not been due to any inherent defect in the system, but to bad design.

If the worm thread be considered as an inclined plane, one will immediately see that the effect of friction is to increase the slope by an amount equal to the angle of friction; this has the effect of deflecting the direction of the resultant pressure and consequently reducing the torque on the wheel. The maximum efficiency of a worm gear may be expressed by the equations:—

$$\eta = \frac{\tan\theta}{\tan(\theta+\mu)}; \text{ the reversed } \eta = \frac{\tan(\theta-\mu)}{\tan\theta}$$

θ is the lead angle and μ the angle of friction.

These two equations show us that the maximum efficiency is obtained when the lead angle approximates 40° − 40′, and that 50 per cent. efficiency obtains when the worm angle is equal to the angle of friction, at which point the gear is irreversible.

The importance of a high lead angle cannot be too strongly emphasised, and it is useless trying to get high efficiency with a low lead angle. In order to obtain this high angle it is necessary to reduce the diameter of the worm as much as possible, which not only gives a better angle, but also reduces the rubbing velocity. Thus one will readily see the reason why so many worms are of small diameter and solid with their shafts, similar to those shown in Fig. 1.

Influence of Speed on Pressure.—Following this are other important factors, namely, the rubbing velocity and its relation to the pressure, the materials used, the area and form of contact. It has often been stated that the permissible pressure multiplied by the velocity is practically constant; this is not so, as it would mean that an increase in velocity would be accompanied by a corresponding proportional decrease in the permissible pressure, hence the same horse-power capacity at all speeds. Within the usual limits the law appears to be that the permissible pressure varies almost inversely as the cube root of the velocity.

Various materials naturally withstand different pressures; for comparatively light loads at somewhat slow speeds the combination may be a cast-iron wheel and a soft mild steel worm; then, for heavier duty, a cast-iron wheel and a hardened steel worm; afterwards, a phosphor-bronze wheel and a hardened and ground worm. The former may be purely motion transmitting, whilst the latter is for transmitting considerable power at high speeds.

Contact between Worm and Wheel.—The next important consideration is the form and the area of the contact between the worm and the wheel. If one takes a section by a plane containing the worm axis and at right angles to the axis of the wheel, one obtains an idea of their contact, as will be seen in Fig. 2. On the involute system their engagement corresponds to a rack and spur, the revolving of the worm causing the imaginary rack to travel along, and so causing the wheel to revolve. Therefore one has a worm whose linear or axial section corresponds to a rack, that is to say, each side of the worm tooth will, on a central section, be a straight line at a predetermined pressure angle. This is the starting-point in manufacture, and it will be noted how this straight line system is used for generating, cutting and inspection, and having once established that basis on the cutters, &c., one knows that when the wheels have been developed by the hob at a specified centre distance they will correctly mesh with the worms. Fig. 3 shows a normal section of the same pair in engagement.

The precise nature of the contact between the gears naturally depends upon the details of their specification and the form of tooth used. This does not appear to have been thoroughly investigated by anyone; but in connection with it there are several important points which should have serious consideration by all interested. Worm gear, unless correctly designed, does not transmit a uniform velocity from one member to another; many gears as ordinarily designed do not give the possibility of such transmission. A close approximation is obtained with gears of comparatively fine pitches, and in those of a high lead angle any error is somewhat "covered up" by the adjacent threads being in action in such a manner that by sustaining an extra proportion of the load distribution the variable velocity period is tided over.

It will be readily understood that if this uniform velocity be theoretically non-existent there will be a tendency for accelerations and retardations to occur as each tooth comes into contact. Often, however, the inertia of the parts prevents a great change in velocity taking place, but it does so at the expense of the gears. The teeth are then called upon to absorb this effect, which results in highly concentrated pressures having to be sustained by certain portions of the wheel teeth, whilst other portions are thus prevented from taking up their share of the load. The transmission of uniform velocity is therefore a most important factor in the accuracy and the utility of dividing wheels for precision work, also on the durability and life of gears when used for high duty transmission.

The usual method of considering the contact by taking a series of linear sections is very liable to give misconceptions, due to the probable absence of the effect of the functions governing the transmission of this uniform velocity.

To consider worm gear as a kind of development from the screw is fundamentally wrong. The pitch surfaces of worm gear are cylinders lying at right angles to each other, hence they only touch in one point; thus the theoretical conditions obtaining in a screw and nut whose pitch surfaces coincide cannot hold good for tangential ones. It must not be overlooked, however, that the theory of the triangle of forces on an inclined plane must hold good. The resultants of the forces acting on the teeth are the resultants of a series of differently inclined planes acting in different directions. In order to obtain an adequate idea of the problem it should be tackled as a three-dimensional one, thereby embodying the rotational effect of the gears.

To put the fundamental condition in a simple manner, one can say that, consistent with the transmission of uniform velocity, the normal to the surfaces from the point of contact must always cut the central plane, which contains the axis of the wheel, at a point on the straight line lying on the wheel-pitch cylinder, and consequently tangential to the pitch cylinder of the worm; thus for every point of intersection between a worm thread and the zone of contact there is always a definite relation between its angular and longitudinal positions. If contact takes place at any other point than this intersection it does so to the detriment of the transmission of uniform velocity.

Furthermore, the effect of the functions governing uniform velocity has a direct bearing upon the real

* Paper read before the Manchester Association of Engineers on October 27, 1917.

rubbing velocity between the gear teeth. Usually this is considered as being the product of the circular pitch-line velocity of the worm and the secant of the lead angle, but when uniform velocity obtains it may be only one-third of that calculated. The real action is then a combination of rolling and sliding, which means that instead of having almost wholly sliding action, the majority of it is replaced by rolling action.

Illustrating the foregoing remarks, Fig. 4 shows four views of worm and wheel of 4 : 25 ratio, designed to transmit uniform velocity. The ribbon-like area stretching across the teeth is the zone of contact between the gears when the worm is rotated in the direction indicated in the end view. The intersections of the worm threads and the zone give the lines of contact between the worm and wheel teeth, wherein it will be observed that the contact line starts on the entering side of the wheel face, where it is practically straight, radial and parallel to the wheel axis; it then travels across the face, with its outer portion gradually lagging behind, and finishes tangentially to the bottom of the tooth.

The top and end view also shows a series of intersections for every 45 deg. rotation of the worm; the alternate lines giving the intersections which correspond to 90-deg. movements, or, as one is considering a worm which has four threads, the line of contact on each thread.

Following the direction of rotation, it will be noted that if the contact for one thread be on the line marked 0, the next thread will have contact on the line marked 1, the following one on 2, &c. Now the distance between 0 and 1 corresponds to one thread, and is therefore equal to a 90-deg. rotation of the worm, but when this movement takes place the actual contact also travels in the same direction as the worm through a distance of approximately 50 deg. to 60 deg., hence about two-thirds of the motion is transmitted by a rolling action, and only one-third by sliding. This means that instead of having the gear teeth rubbing against each other, say, at 1,000 ft. per minute, rolling action is so introduced that the real rubbing velocity is reduced to about 350 ft. per minute.

A further zone of contact for similar gears (4 : 25 ratio, 15-deg. pressure angle, 30-deg. lead angle), but designed upon ordinary lines (see Fig. 5), is of special interest. In this case the zone is actually interrupted near the central plane, and almost the whole of the contact consistent with uniform velocity takes place on the approaching side of the worm wheel, meaning, therefore, that if the worm be placed in engagement with the wheel, contact between their teeth takes place on the extremities of the worm, when, in many cases, the centre teeth have practically no contact. There is also a duality of the lines of contact, which, during the revolution of the gear gradually travel towards each other, meeting just beyond the central plane, where contact entirely ceases.

On account of the contact-point not travelling in the direction of rotation to any appreciable extent, the rubbing velocity has practically its full theoretical value, whilst rolling action is almost non-existent. The research work concerning the contact and the real action which takes place in worm gear has enabled one to account for a large number of inherent difficulties which have often been regarded as insoluble, but it is too lengthy to be further considered here; at the same time it might be well to note the comparison between the zones of these two gears, which are identical with the exception of the contours of their teeth.

A study of the zones of contact for a series of gears reveals to one not only how many teeth are in actual simultaneous contact, but also how many times the projected area may be said to be in continuous contact, thus indicating how much of the load should be proportioned to each wheel tooth; usually it varies from 1.5 to 3 times the projected area. A fine pitch gives more teeth in contact, but on a lesser projected area than a coarser pitch; the advantage, however, appears to be in favour of the latter.

Characteristics of Standard Series.—The characteristics of a standard series of worm gear are shown in Fig. 6. The curves indicate the probable advantageous number of threads and teeth to use in the composition of a required ratio, also how the lead angle, the pressure angle, and the heights of the teeth vary with the number of the threads in the worm. It also shows the average pitches in contact, and the respective load-carrying capacities, together with the gross efficiencies which, with ordinary manufacture, are obtained by the unit as a whole; this of course includes all frictional losses due to internal and external causes.

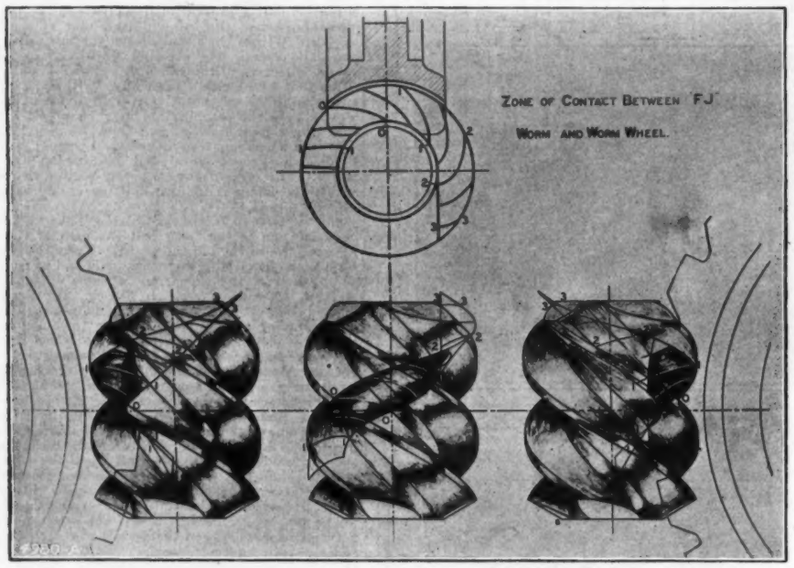


Fig. 4. Zone of Contact between "F. J." Worm and Wheel.

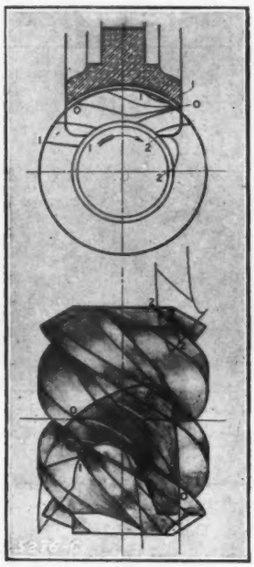


Fig. 5 Zone of Contact between Ordinary Worm and Wheel.

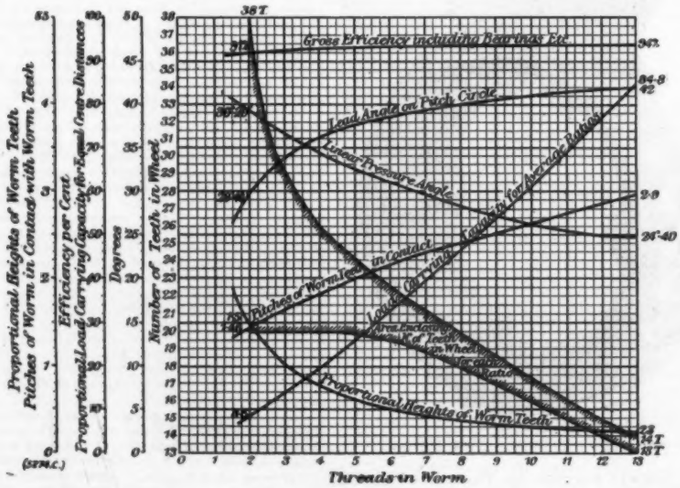


Fig. 6. Characteristics of "F. J." Standard Series of Gears.

Thermal Considerations.—The amount of heat generated is another factor to be considered. All frictional losses produce heat, and if the amount of heat generated be greater than the amount radiated, dissipated or conducted away, the temperature of the gear unit will rise. When it rises above a certain point (about 250 deg. F.), the oil film breaks down and lubricating value ceases, but they are usually run at a nice warm temperature (150 deg. F. to 175 deg. F.).

Thus it is that the thermal characteristic has also to be considered, for which purpose one must know, in addition to the foregoing, the load factor or the proportional time the gear will run on various loads, and the thermal capacity of the case, or how many British thermal units it can radiate or conduct away at various temperatures. By these data one can predetermine the temperature rise of the gear unit at the end of any period of running under a certain load factor.

The author has known cases of gears failing, even when they have been transmitting only one-quarter or one-third of their actual capacity, solely on account of the gear cases containing them not having sufficient radiating capacity to get rid of the heat generated, and as the thermal capacity of the gear case is usually the limiting factor of the unit, the gears can often be subjected to considerable overloads for short periods without any injury. One of the great advantages of worm gear, *i.e.*, its being able to transmit great reductions between two members only, is likely to be nullified if this thermal factor be overlooked.

(To be continued.)

War Time Efficiency.—An article in the quarterly review issued by the Electrical Apparatus Company, Limited, Vauxhall Works, Lambeth-road, London, records that although the staff during the past twelve months numbered 263, as against 319 in 1913, the output was just twice as great. This is the more notable since, in the spring of 1913, the directors had come to the conclusion that the output could not be increased without enlarging the works, complete plans for which had, in fact, been prepared. Overtime was, moreover, the rule in 1913, and yet, as stated, the output was only one-half of that of to-day, although many qualified men have been replaced by boy and girl labour. The improvement is in part attributed to an improvement and simplification of designs.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

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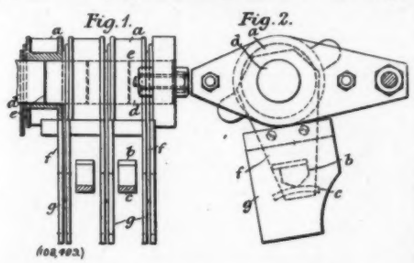
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

ELECTRICAL APPARATUS.

108,381. W. T. Henley's Telegraph Works Company, Limited, London, and W. S. Wakefield, Northfleet, Kent. Electric Cable Terminals. (6 *Figs.*) September 8, 1916.—This invention relates to shoes or sockets for electric cable terminals. The improved shoe or socket of the present invention has, in cross-section, the shape of an upstanding arch *a*, one haunch *b* of which extends outwards laterally to form a flange, (Fig. 1), or both haunches *b* of which extend outwards laterally in opposite directions to form flanges (Fig. 2), which at their outer extremities are recurved to constitute integral continuations of the base *d*, which may be flat, the flange or flanges *b*

and base *d* being separated by a space *e*, and the whole presenting substantially the form of a tube flattened out laterally towards one or both sides, but more open at one side or the centre of its width, where the arch affords room for the insertion of the conductor. The space *e* separating the flange or flanges *b* from the base *d* permits of the crown of the arch being drawn down towards the base by means of screws *f* passing through holes in the base and entering threaded holes provided in the flange or flanges, or in a separate plate *g*, so that when the end of the conductor has been inserted between the arch *a* and the base and the screws tightened, the conductor will be firmly clamped in the socket. (*Accepted August* 15, 1917.)

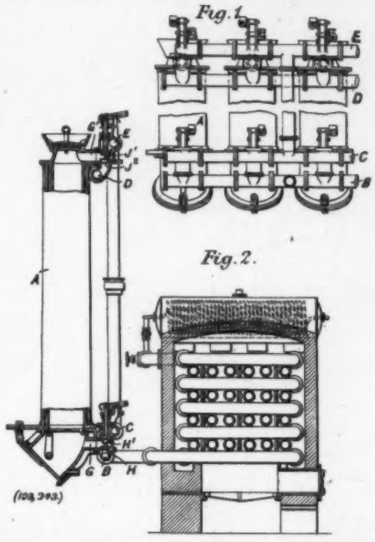
108,403. G. Ellison and J. Anderson, Perry Barr, Birmingham. Electric Motor Controllers. (3 *Figs.*) October 21, 1916.—This invention relates to electric motor controllers of the type in which a number of movable contacts are mounted on a spindle. The invention comprises the provision of air gaps in the magnetic circuit, either by the use of a sectional core or by electrically separating the pole pieces from the core. A number of coils *a*, approximately equal in width to the pitch of the fixed and movable contacts *b* and *c*, are wound and coaxially mounted so that the like poles lie together. The core of the coils is formed from a number of sections *d* of iron, each section extending approximately half-way into an adjacent pair



of coils, leaving an air gap *e* between each pair of sections or core parts, which is preferably filled with a disc or plate of insulating material. Between each pair of coils, and in magnetic connection with the core, is a platelike pole piece *f*, constructed to extend laterally into the space between a pair of contacts like the shields usually employed. Preferably each pole-piece has arranged on one or both sides a covering of non-conductive and non-combustible material, forming a shield *g*. By the arrangement above described a strong magnetic field is produced in a direction parallel to the axis of the coils or the spindle carrying the movable contacts, and by such field the arcs set up when separating the contacts are extinguished in the well-known manner. (*Accepted August* 15, 1917.)

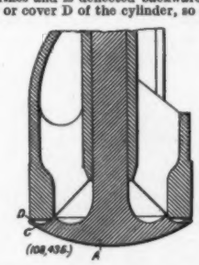
GAS ENGINES, PRODUCERS, HOLDERS, &c.

108,343. F. Lamplough, London, and Oil Extractors Limited, London. Distillation of Coal. (2 *Figs.*) July 28 1916.—This invention relates to the low-temperature distillation of coal. The present invention is of a process for the low-temperature distillation of coal, of the type consisting in bringing superheated steam or other gaseous heating medium, preferably at low pressure, into contact with the coal to effect the distillation. The apparatus comprises a battery of vertical retorts A, built with two lower parallel mains B, C, and a pair of upper parallel mains D, E. The main B is fed with superheated steam, whereas the main C, hereinafter referred to as the by-pass feed, is connected by a downtake F with the uppermost main E, which latter is hereinafter referred to as the by-pass delivery. The lower main D of the two upper mains is the gas main. The mains B, C discharge into a series of inlet ducts G, one for each retort. Communication between the said mains and each inlet duct G is under the control of two opposed mushroom valves H, H_1. The mains D, E are similarly connected through valves J_1, J_2 to an outlet duct G_1. Normally superheated steam is admitted from the main B through the valve H into the bottom of each retort, and the distillate escapes through the duct G_1, under control of the valve J, into the gas main D. Normally the valves H_1 and J_1 are closed, and if the retorts are all equally packed, all will be approximately equally heated. This, however, rarely is the case, and in the result some retorts receive more steam than others, and in some the action tends to proceed relatively too rapidly, and in others relatively too slowly. When, therefore, it is seen that the action in one retort is proceeding too slowly, one or more of the valves J_1 are opened slightly, and the corresponding valves J slightly closed. This diverts into the by-pass delivery E some of the hot gas, which otherwise would have been



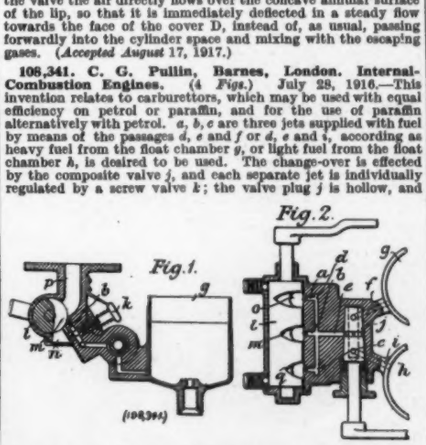
delivered into the gas main D. At the same time the valve H_1 on the retort where matters are proceeding too slowly is opened, and a hot gas from the other retorts passes from the main E by way of the downtake F and the main C into this last-said retort to promote the distillation there. (*Accepted August* 15, 1917.)

108,436. J. McKechnie, Barrow-in-Furness. Internal-Combustion Engines. (1 *Fig.*) March 24, 1917.—This invention relates to the air or scavenging valves of two-stroke cycle internal-combustion engines. According to this invention, the mushroom head A of the said valve is formed with a peripheral lip C, providing a concave annular surface against which the incoming air strikes and is deflected backwardly and outwardly against the end or cover D of the cylinder, so as to displace the



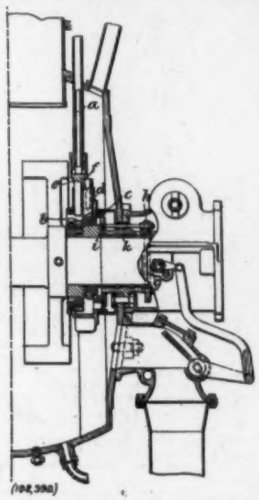
burnt gases from the cylinder end towards the usual exhaust ports without substantial admixture. The lip is preferably situated immediately outside the seating surface, and on opening the valve the air directly flows over the concave annular surface of the lip, so that it is immediately deflected in a steady flow towards the face of the cover D, instead of, as usual, passing forwardly into the cylinder space and mixing with the escaping gases. (*Accepted August* 17, 1917.)

108,341. C. G. Pullin, Barnes, London. Internal-Combustion Engines. (4 *Figs.*) July 28, 1916.—This invention relates to carburettors, which may be used with equal efficiency on petrol or paraffin, and for the use of paraffin alternatively with petrol. *a*, *b*, *c* are three jets supplied with fuel by means of the passages *d*, *e* and *f* or *d*, *e* and *i*, according as heavy fuel from the float chamber *g*, or light fuel from the float chamber *h*, is desired to be used. The change-over is effected by the composite valve *j*, and each separate jet is individually regulated by a screw valve *k*; the valve plug *j* is hollow, and



preferably is fitted with a cylindrical gauze strainer. The jets *a*, *b*, *c* each open at points in a line on the surface of the casing of the rotating barrel *l*, just before the entrance to the mixing chamber, which entrance is closed by the barrel when it is rotated in its seating by its control lever; the passage *n* may be constructed of streamline form, and divides into three separate mixing chambers, such as *p*, above the entry-point of the jets *a*, *b*, *c*; separate and continuously expanding tubes connect to these mixing chambers, and conduct the gases therefrom to the induction pipe of the motor. The rotating barrel valve is made with parts cut away as shown at *o*, *m*, *q*, opposite each jet *a*, *b*, *c* respectively, the location of the cut-away portions being such that they come into action (on rotation) at different times, and besides giving correct admixture of air for each jet, ensure that the mixture and volume are correct when all jets are fully open, and similarly in proportion for intermediate stages. One means conducing to this end is the construction of the valve *l*, so as to close both the air passage *n* and a particular fuel jet, say *b*, simultaneously, each jet and its air passage being similarly closed, though at different times. (*Accepted August* 15, 1917.)

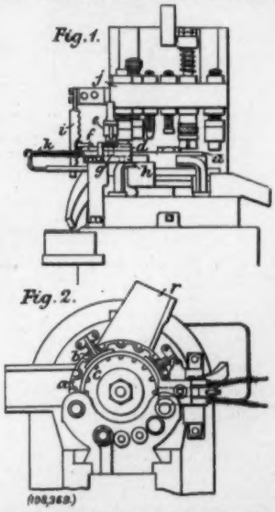
108,390. C. B. Redrup, Bexleyheath, Kent. Internal-Combustion Engines. (1 *Fig.*) September 25, 1916.—This invention relates to valve mechanism for internal-combustion engines of the type in which the exhaust valve or an auxiliary air valve is adapted to be opened at or near the end of the induction stroke for the purpose of admitting air to the cylinder in order to produce a mixture of the requisite strength, means being provided for varying the amount of air thus drawn into the cylinder. The invention provides an improved form of valve mechanism of the above character, and consists in valve mechanism of the type referred to, comprising an air inlet valve adapted to be mechanically opened at or near the end of the induction stroke, combined with means for varying the amount of opening that is mechanically given to the valve for the purpose of varying the amount of air drawn in through such valve. The exhaust valve (not shown) is actuated by means of a rod *a* operated by the main cam *b* when the valve is to serve as an exhaust, and by a second cam *c*, either directly or through the



intervention of a suitable arm or link, when the valve is to be opened towards the end of the induction stroke to allow an additional body of air to enter the cylinder. Thus the cam *c* acts upon an auxiliary tappet *d*, a collar *e* on which co-operates with the shouldered portion *f* to give the auxiliary lift or opening to the valve for the purpose of admitting air into the cylinder at or near the end of the induction stroke. With the object of enabling the amount of movement of the valve in this latter case to be varied, the cam *c* and the face of the tappet *d* adapted to engage therewith are inclined as shown, so that by moving the cam relatively to the tappet, so that it moves across the face of the tappet, the amount of lift mechanically imparted to the valve will be varied, depending upon the position of the tappet *d* relatively to the cam *c*. The position of the cam *c* may be adjusted by means of a cam *g* acting upon a collar *h*, which is tied to the collar *i*, carrying or engaging the cam *c* by bolts *k*. The cam *g* may, if desired, be hand-operated, and work in conjunction with a suitable scale. (*Accepted August* 15, 1917.)

GUNS AND EXPLOSIVES.

106,369. D. G. French, Birmingham Metal and Munitions Company, Limited, and P. H. Mills, Birmingham. Manufacture of Cartridges. (2 *Figs.*) August 16, 1916.—



This invention is an improved machine for use in the manufacture of rifle cartridges charged with powdered or like explosive material, the machine being of the type in which the performance of the filling and the subsequent operations required for the

completion of a cartridge are effected by appliances which are actuated by a single slide or plunger working in conjunction with a rotating feed table or its equivalent. An ordinary intermittently rotated horizontal table *a* is used, this being formed with two concentric rings or recesses *b* and *c* for the cartridge cases and bullets respectively. The cases and bullets are placed in the table recesses at the feeding platform *r*. Above a portion of the periphery of the table are arranged the filling device and the tools employed in the necking, bulleting and other finishing operations. The filling device comprises a fixed box *d* provided with a feed channel *e*, and a slide *f* containing a measuring chamber *g*. In one position the latter is supplied with explosive material from the channel *e*, which is connected by a flexible pipe with a supply hopper (not shown), and in another position it discharges through an outlet *h* to the cartridge case carried beneath it by the rotating table. While in the first position the slide closes the outlet, and while in the other position it closes the delivery end of the feed channel. Motion of the slide is effected in one direction by a cam bar *i*, secured to a vertically movable slide *j*, and in the other direction by springs *k*. To ensure proper filling and delivery of the contents of the measuring chamber the slide containing the said chamber has imparted to it a vibratory motion, this being effected by the provision of notches or corrugations, as shown, in the operative edge or surface of the cam bar. (*Accepted August* 15, 1917.)

MOTOR ROAD VEHICLES.

108,389. G. C. Hayes, Paddington, London, and C. C. D. Steel, Kilburn, London. Motor Road Vehicles. (2 *Figs.*) September 25, 1916.—This invention relates to the steering gear for motor vehicles in which the steering wheels 1 are caused to turn on posts 3, on a non-rotatable axle bar 2, by steering arms 4 connected by a tie-rod 5, and the invention

Fig.1.

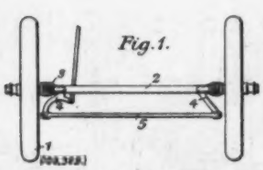
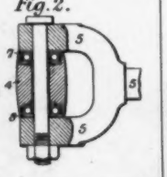


Fig.2.



consists in providing anti-friction devices 7, 8, such, for example, as ball or roller bearings, at the place of connection of the steer arms 4 with the tie-rod 5, so that wear and, consequently, the liability of play between the said parts is reduced to a minimum, thereby rendering the gear more responsive in action and ensuring simultaneous turning of the steering wheels. (*Accepted August* 15, 1917.)

PUMPS.

108,394. G. H. Boot, Bearwood, Smethwick. Rotary Pumps. (2 *Figs.*) September 28, 1916.—This invention relates to rotary pumps of the type wherein the impellers comprise a pair of toothed wheels rotating in engagement in the pump chamber. The pump chamber is formed from a rectangular boxlike part *a*, having open ends, which are respectively closed by the pump frame or standard *b* and an end cover *c*. The intermeshing toothed wheels *d* forming the impellers are rotatably mounted within the pump chamber on gudgeons carried within bearings formed in the pump frame and the end cover *c*. One of the gudgeons of one of the toothed wheels is extended to the

Fig.1.

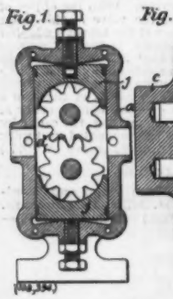
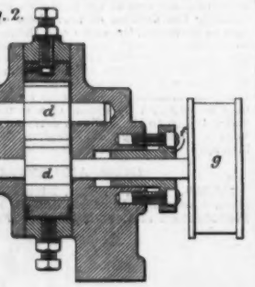


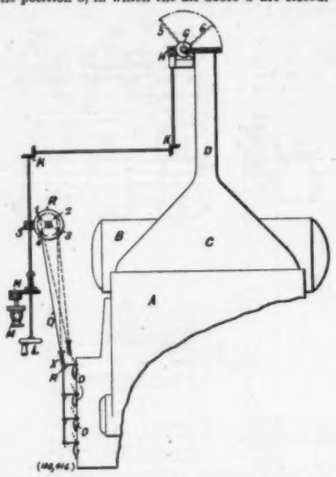
Fig.2.



outer side or end of the standard, through a suitable stuffing-box *f*, and has a driving pulley *g* secured thereto. Within the pump chamber *a* there is mounted a pair of blocks *j*, made to a sliding fit between the walls of the chamber and each having a concave surface corresponding with the diameter of the impeller which is to rotate in contact with or closely adjacent to it. The blocks can be fitted with leather or other packing. Adjustment of each block with relation to its wheel is effected by a screw *l* projecting through the pump chamber, having its inner end abutting upon or engaging with the block. (*Accepted August* 15, 1917.)

SHIPS AND NAUTICAL APPLIANCES.

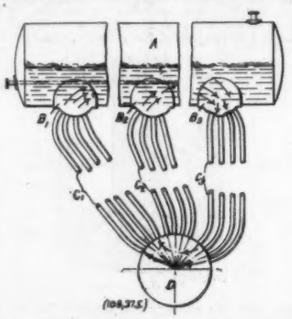
108,416. H. E. Yarrow, Scotstoun, Glasgow. Submarine Vessels. (9 *Figs.*) November 24, 1916.—The invention relates to improvements for closing the top of the funnel of a submarine vessel when it is intended to submerge the vessel. According to the invention a hinged valve *e* is provided, which can be operated from within the submarine to close the funnel aperture when the vessel is submerged, and the means operating the valve are either so arranged that at the first motion the oil fuel is shut off from the burners, the air doors are then closed to prevent the products of combustion from escaping into the stokehold, and, finally, the funnel aperture is closed to prevent access of water, or these operations are performed simultaneously. A is a boiler of the water-tube type, B the steam drum, C the uptake, D the funnel, E a valve for closing the top of the funnel, when the vessel is submerged. G is a worm wheel rotated by a worm H adapted to open or close the valve E. The worm H is rotated by spindles and bevel gearing K. Assuming the valve E is in the open position, the rotation of a hand wheel L closes the oil fuel supply to the burners at a valve M by means of gearing N. When this valve is completely closed a spring clutch slips. While the hand wheel L is closing the valve M a worm wheel R, engaging with a worm S on the spindle operated by the hand wheel, moves from a position 1 to a position 2, but during this motion a connecting rod Q, pivoted to a radius of the wheel R and hinged to levers P operating air doors O of the furnaces, is only moved vertically by the small amount represented by the versed sine of the arc between positions 1 and 2. A further movement of the hand wheel L brings the wheel R into the position 3, in which the air doors O are closed. While



the worm wheel R is moved from position 1 to position 3, the funnel valve E is moved from position 5 to position 6. A further rotation of the hand wheel will move the wheel R from position 3 to position 4, and will close valve E. The small vertical movement of the connecting rod Q, between positions 3 and 4, is taken up by a spring X. (*Accepted August* 15, 1917.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

108,375. E. C. R. Marks, London (*the Firm Deutsche Babcock and Wilcox Dampfkesselwerke A.G., Oberhausen, Rheinland, Germany*). **Water-Tube Boilers.** (2 *Figs.*) August 26, 1916.—This invention relates to water-tube boilers of the type employing water-tubes disposed between upper and transversely lower drums. According to the present invention, the groups of water tubes C_1, C_2, C_3, rising from the transversal lower drum D

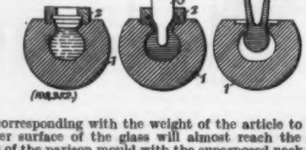


(or drums) are not inserted immediately in the longitudinal upper drum A, but are secured into transverse tube walls or tube plates B_1, B_2, B_3, and enter these transverse tube walls or tube-plates in such a manner that the water rising in the water tubes is directed, and therefore flows mainly in the longitudinal direction of the upper drum, so that all whirling up of the water is avoided. (*Accepted August* 15, 1917.)

MISCELLANEOUS.

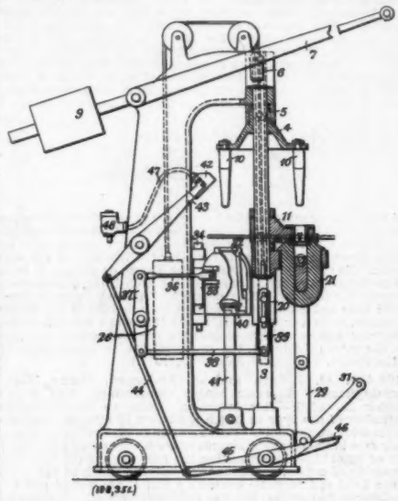
108,352. E. Roirant, St-Ouen, Seine, France. Manufacture of Hollow Glass Articles. (5 *Figs.*) August 1, 1916.—This invention has reference to the manufacture of what are known as "pressed-blown" glass articles. The treatment and shaping of parisons for "pressed-blown" articles involves in the present invention, as in the practice now prevailing, the employment of a parison mould, a neck mould superposed thereon, and a pressure plunger. The invention has for object to obviate the difficulties that pertain to the processes now in use for manufacturing "pressed-blown" glass articles. In the process of manufacturing "pressed-blown" articles, according to this invention, a relatively short parison mould 1 is employed, the capacity of which is such that on introducing glass of a

Fig.1. *Fig.2.* *Fig.3.*



weight corresponding with the weight of the article to be made the upper surface of the glass will almost reach the plane of juncture of the parison mould with the superposed neck mould 2. Under these conditions a very short upward movement of the glass, under the influence of the pressure plunger 3, will suffice to fill the superposed neck mould. The short parison thus formed is then submitted to a mechanical drawing action, which acts on, and stretches, the whole of the parison to the requisite length for finish blowing. The mechanical drawing-out of the whole of the parison is effected by moving the superposed neck mould 2 away from the parison mould 1, or *vice versa*, or by moving the superposed neck mould and parison mould apart simultaneously. (*Accepted August* 15, 1917.)

108,351. E. Roirant, St-Ouen, Seine, France. Glass-Shaping and Blowing Machines. (5 *Figs.*) August 1, 1916.—In known machines for the manufacture of "pressed-blown" articles and comprising a single set of moulds, *i.e.*, a parison mould, a superposed neck mould and a finishing mould, it is necessary for the finished article to "set" in, and to be removed from, the finishing mould before the preparing and shaping of a parison for another article can be undertaken. According to the present invention, the machine possesses only one set of moulds, but these moulds are so arranged and correlated that the preparing and shaping of a parison for an article takes place simultaneously with the "setting" of the previous parison. 4 is a carrier rotatably mounted on, and also movable vertically in relation to, a shaft 3. The carrier 4 has a collar 5, to which links 6 are connected; the links 6 are also connected to a lever 7, normally held in the position shown by a counter-weight 9. The carrier 4 carries pressure plungers 10, of which two are provided. 11 is a second carrier rotatably mounted on the shaft 3, but not movable vertically in relation thereto. The carrier 11 serves as a support for the neck mould. 20 is a third carrier movable vertically, but not rotatable, in relation to the shaft 3. The carrier 20 serves to carry the parison mould 21. The carrier 20 and parison mould are constrained to occupy the positions in which they are shown by a weight 26. The carrier 20 is connected to a pair of bell-crank levers 29, connected together by a cross-bar 31. The bell-crank levers 29 are actuated by the operator, who presses on the cross-bar 31 with



his foot; when this happens the carrier 20 and parison mould are moved downwardly against the action of the weight 26, which automatically returns the parts to the position shown when the operator removes his foot. The finishing mould 32 comprises, as usual, two halves, and each of these halves is mounted in and carried by a holder 33, mounted on a pin 34. Each of the holders 33 is connected through a link 36, a lever 37 and a link 38 to the lower end of a plate 39 adjustably mounted on the carrier 20. From the foregoing description it will be understood that vertical movements of the carrier 20 will be transmitted to the links 36, and that these links will be reciprocated horizontally. The reciprocation of the links 36 affects the finishing mould and causes it to open and close, the opening and closing movements being simultaneous with the downward and upward movements respectively of the carrier 20 and parison mould 21. 40 is the bottom of the finishing mould carried on the upper end of a vertically adjustable rod 41. 42 is a bell-shaped closure device carried on a lever 43 connected by a link 44 with a lever 45 formed with a pedal 46, which, when depressed, causes the device 42 to be lowered towards and to seat itself on the upper end of the finishing mould. To the bell-shaped closure device is connected the one end of a flexible tube 47, the other end of which is connected with a valve casing 48, in connection with a source or supply of air under pressure. Through the valve casing 48 projects downwardly a valve stem, which is adapted to be actuated by the lever 43 when moved in response to the pressure of the operator's foot on the pedal 46. (*Accepted August* 15, 1917.)

GERMANY AND CHINA.—German papers have abandoned all restraint in their comments upon the recent developments in China, and what this means to German industry, German finance and German commerce. The old Anglophobe journal, the *Hamburger Nachrichten*, especially gives vent to much bitterness in summing-up what Germany had worked up and has now lost in China. After the Boxer insurrection Germany pushed ahead and had become second as far as commerce went, and was in a fair way of overtaking England. This was achieved apart from the ability of the Germans to adapt themselves to Chinese ideas, through the group of large banks which combined and formed the German Asiatic Bank, and the enterprise of the German shipping world, especially the Hamburg-America Company and the North German Lloyd lines. The bank became the leading factor in all financial transactions between Germany and China, and the middleman in the matter of German railway, mining and other concessions in China. Until 1905 some 350,000,000 marks of German capital was invested in China. A sum of 90,000,000 marks was expended on the Tientsin-Pukow Railway, besides large capital on the Canton-Hankow and the Tachets-chuan railways; large amounts were also invested in loans. Adding to all this the capital which private individuals and many large firms had invested in Chinese towns such as Shanghai, Tientsin, Hankow, Canton, Chinanfu and Tsingtau, the aggregate of German capital invested in China may be put at 1,000,000,000 marks (50,000,000*l.*).